JOURNAL

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OF THE INSTITUTION OF ELECTRICAL ENGINEERS

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The Institution is not, as a body, responsible for the opinions which are expressed in the *Journal*, unless it is stated that an article, letter or announcement officially represents the Council's views.

JOURNAL

OF THE INSTITUTION OF ELECTRICAL ENGINEERS

VOLUME 2 (NEW SERIES) NUMBER 16 APRIL 1956

ANNUAL BUT NOT SO GENERAL

NOTICES THAT ANNOUNCE THE ADVENT OF Annual General Meetings rarely send thrills of anticipation down the spines of their readers. Too often such meetings of the associations into which men and women band themselves for service, pleasure or profit are notoriously ill-attended compared with the regular activities for which the associations exist. Rumours of dramatic resignations from the committee will sometimes pack the A.G.M. of a vigorous golf club, and the manoeuvres of financiers may do the same for that of a public company with a conservative dividend policy, but usually most back-bench members of a society are glad to leave the ordering of its affairs to an elected committee or council. They gratefully escape from entering yet another evening fixture in the crowded columns of their post-war diaries by quietly ignoring the A.G.M. This attitude, though understandable, cannot be commended: just as people should refuse election to committees unless they are prepared to attend the committee meetings, so people should not join societies unless they intend to support the Annual Meetings, if not every year, at least from time to time. Even when the members of a society are wholly satisfied with the administration of their elected officers, it is good and proper that they should once a year formally tell those officers this. They who give time and energy to administering a society as an honorary service to their fellow members have a right to some recognition—critical or appreciative—by those members. An A.G.M. is the fitting occasion to show this.

Unfortunately the Annual General Meeting of The Institution now forms no exception to the rule of poor attendance. In the past few years the lecture theatre has seen at each A.G.M. about 60 members, or less than 0·2% of the total membership. It is true that the Bye-Laws of The Institution in their wisdom fix the quorum for the A.G.M. as 12 members, but this figure must be construed as a safeguard against wasting the time of members that do turn up rather than an indication of satisfactory attendance. Probably many members do not realize that while, under Bye-Law 73, only Corporate Members and Associates have the right to vote on resolutions at the A.G.M., the Council welcome the attendance of members of every class at it.

At the meeting the Council's Report for the twelve months ending on the 31st March and the Annual Accounts for the previous calendar year are presented and comments on them are invited from members. In addition members may (with the approval of the Council) transact any other business they wish to, provided that notice has been sent to the Secretary at least seven days before the meeting. The A.G.M. is in fact the one regular meeting in the year at which members have an opportunity to speak on Institution activities or policy.

Apart from the opportunities it affords those who have grievances to air or complaints to make, what merits are there in members attending, and giving their views at, the Annual General Meeting? Broadly speaking, the Council can keep themselves informed about members' views on Institution policy by three methods: personal contact between Members of Council and other members; letters written by members to the Secretary; and views expressed at Annual and Special General Meetings. At the A.G.M. in May the Council should be able to expect to receive each year some indication of what members are feeling about the more active questions that face The Institution, and about the service it gives to members. Adverse criticism is not particularly looked for, though members have every right to make it if they wish; constructive ideas for the future are the vitamins of a healthy discussion and members can serve The Institution well by feeding the meeting with them. To-day, as the Annual Accounts for 1955 emphasize too well, the need for economy is paramount, and some members may have worth-while suggestions about this. They should remember, however, that the Finance Committee have examined the question thoroughly in the last year, and proposals for economy in, say, publications, while plausible at first sight, often reveal hidden snags over, perhaps, advertisements or reproduction of half-tone illustrations. However, even when a suggestion has already been considered by the Council or one of its committees and rejected as impracticable, to have this action ventilated in public is useful. The Council would be the first to agree that placid acquiescence by members with all their decisions is not a healthy sign; they would not wish for an opposition party, but a little back-bench probing at the annual Question Time can only do good.

Moreover the occasion of The Institution's A.G.M. is now not just a business meeting. It has been the Council's recent practice to arrange at the close of the A.G.M. for a lecture on a subject that is only loosely coupled to engineering. This is not so much jam on the bread-and-butter as entertainment and instruction for what should be the largest gathering of members in The Institution's year. In 1956 the lecturer is Sir Gordon Russell and he will speak on 'Appearance Design'. Visions of Sir Gordon's furniture, of his work for the Council of Industrial Design, and of the startling variation in the architectural quality of present-day electrical equipment, whether electric locomotives, switchboards or portable radio sets, show us that we are in for a lively and fascinating evening on the 17th May. Business will join hands with pleasure to draw members to Savoy Place on this important day.

An Electrical Engineering Review

DIESEL-ELECTRIC TRACTION

This review is a simple but authoritative account of Diesel-electric traction, written by one of the electrical industry's leading experts on the subject. By 1975, Mr. Whyman estimates, 70% of the motive power used on the world's railways will be Diesel-electric—an estimate that points to the ascending importance of this form of power in the economy of the twentieth-century world. No doubt Britain ought to be hesitant about hitching too many of her wagons to oil, for electrical energy from imported atoms may prove more assured than mechanical energy from imported petroleum, should international upheavals imperil her trade. But such upheavals are the stuff of speculation, and there are cogent economic reasons for extending the use of Diesel-electric traction in these islands, as indeed the British Transport Commission is doing; and in the countries of the world that are blessed with oil-fields, Diesel-electric motive power is usually the first choice for railway traction. It may be noted that a progress review of straight-electric traction will be published in the Proceedings within the next few months, and the present electrical engineering review is in some measure complementary to it.

F. WHYMAN, B.SC.TECH., MEMBER

THE DEVELOPMENT OF DIESEL-ELECTRIC TRACTION

DIESEL-ELECTRIC traction was applied spasmodically and in small quantities from the early nineteen-twenties onwards in Europe but it has been solidly established by a tremendous application in the United States in the later nineteen-thirties, throughout the 1939–45 War and in the post-war years; it appears certain, for the foreseeable future, to be the most common form of motive power on the world's railways.

The reasons for this vast development, after a long slow start, were somewhat diverse and initially were mainly peculiar to North America. However, while complex and apparently obscure, they were economically potent. Some of these reasons were:

(*a*) The Diesel engine had been developed to possess great reliability and was the most efficient means for converting the chemical energy of oil into mechanical energy.

(*b*) Oil in vast quantities was becoming increasingly available at low cost.

(*c*) Coal was becoming artificially scarce and increasingly expensive.

(*d*) Labour costs were rising steeply and the ability to operate Diesel-electric locomotives in multiple units by a single driver enabled much heavier trains to be operated by smaller crews at higher speeds, so that the driver and guard costs per ton-mile could be reduced to a fraction of those of steam traction.

(*e*) The cost of locomotive maintenance and general servicing was found to be a small percentage of that of steam locomotives.

(*f*) Railways were experiencing increasing financial difficulties, and road competition based on the rapid development of the internal combustion engine often jeopardized their survival.

(*g*) The American genius for mass production of a few types of locomotive in enormous quantities made possible the provision of cheap locomotives in a country of high labour cost.

(*h*) The parlous state of many railways made financiers unwilling to finance fixed works such as are required for railway electrification. They were willing, however, to buy Diesel-electric locomotives and hire them to railways where they could be withdrawn if the hire cost was not regularly paid.

The introduction of Diesel-electric locomotives was found to reduce sharply the overall railway operating costs per ton-mile and per passenger-mile and gave a new lease of life to the North American railways.

During this hectic American railway revolution most of the underlying reasons for the use of Diesel-electric traction were more slow to apply in the Old World, and this, coupled with a greater innate conservatism, caused Diesel-electric traction to be introduced initially in special conditions only. To-day, however, changing world conditions make an extensive application of Diesel-electric traction inevitable.

Before leaving the economic reasons for Diesel-electric traction, we should consider the place of straight-electric (railway) traction, to try to predict its relative application in the future.

First it can be said that for large urban areas in any part of the world an effective suburban railway service can be provided only by straight-electric multiple-unit coach traction and an increasing application of it is unchallengeable.

For main-line railway work where there is heavy traffic and other conditions do not dictate the use of infrequent very large trains, straight-electric traction is generally the cheapest and best and its increasing use other than in North America is assured. In North America the infrequent, very heavy trains of up to 14000 tons make straight-electric traction unattractive, and as the economics of these railways inhibit the raising of capital for the fixed works of electric traction, the wide use of it for main-line railways appears quite impossible.

Outside North America, the expansion of straight-electric traction to certain routes will still leave a large percentage of main-line railways the future preserve of Diesel-electric traction.

To sum up the world position, excluding North America, it would appear likely that by 1975 the steam

locomotive will be to all intents and purposes extinct, and motive power will be distributed approximately as: straight-electric, 25%; Diesel-electric, 70%; and various systems such as Diesel-mechanical, 5%.

Diesel-electric traction is thus becoming increasingly important.

THE DIESEL-ELECTRIC LOCOMOTIVE

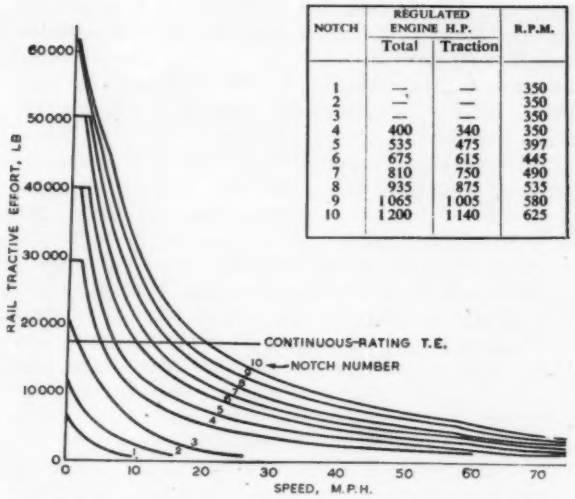
The Diesel Engine

The Diesel-electric locomotive employs a Diesel engine to drive a generator supplying energy to traction motors which drive some or all of the locomotive axles. The characteristics of the electric transmission are such that, over a band of locomotive speeds generally not less than 70% of the maximum road speed, substantially full engine power is utilized for application to the locomotive wheels. The relevant part of the tractive-effort speed curve is thus substantially a hyperbola, the product of tractive effort and locomotive speed being to a first approximation constant.

Fig. 1 shows a family of such performance curves for an 85-ton 1 200h.p. 6-motor 6-axle Diesel-electric locomotive, each of the curves for notches 4 to 10 being based on a particular Diesel-engine speed and power; any of these particular speeds and powers are available to the driver at any time.

It will be seen that below a speed of 6m.p.h. the maximum power curve departs from the hyperbola, the tractive effort being automatically limited to 62000lb, which is the maximum the locomotive adhesive weight of 85 tons can normally exert without slipping of wheels on the rails. At speeds above 6m.p.h. up to 59m.p.h. full engine power is utilized, and above this speed the traction motor horse-power is inversely proportional to speed since the generator has reached its maximum voltage and the traction motors their weakest field strength. It will be seen that over about 70% of the locomotive speed range full engine power is utilized. This range can readily be extended from 59m.p.h. up to the maximum locomotive speed but the cost and weight of the electric transmission would be increased, and as the operating advantage would be negligible, it is rarely done.

NOTCH	REGULATED ENGINE H.P.		R.P.M.
	Total	Traction	
1	—	—	350
2	—	—	350
3	—	—	350
4	400	340	350
5	535	475	397
6	675	615	445
7	810	750	490
8	935	875	535
9	1 065	1 005	580
10	1 200	1 140	625

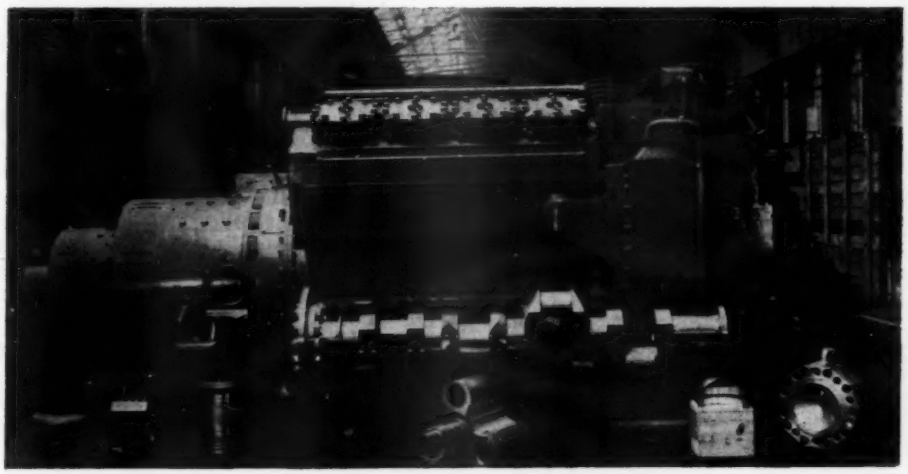


1 *Performance curves of a 1 200h.p. Diesel-electric locomotive*

The Diesel engine itself is the most important component of a Diesel-electric locomotive and with its essential accessories is responsible for about a third of the capital cost and the major part of its wear-and-tear maintenance cost and failures.

Two main types are available, namely the two-stroke-cycle and the four-stroke-cycle engines.

The two-stroke engine. This is essentially the simpler in construction, and in its form illustrated in Fig. 2, has no valve gear and few moving parts. Inspiration of combustion air is usually achieved by an engine-driven quantitative delivery type of blower mainly for scavenge



2 *A 1 200 h.p. Diesel-engine generator set and various main-engine components*

purposes. The specific fuel consumption is at present between 3 and 10% greater than that of its four-stroke counterpart, but most of the world's Diesel-electric locomotives are powered by the two-stroke engine, indicating that its advantages offset its higher specific fuel consumption.

The four-stroke engine. Such an engine is necessarily provided with valve gear, and it has remained competitive with the two-stroke engine solely because of the progressive development of the exhaust turbo-blower, which utilizes what would otherwise be mainly exhaust-gas waste energy to drive a centrifugal type of blower. This greatly increases the weight of air inspired on every other down stroke, thus allowing substantially more fuel to be burnt and more power to be developed. Its greatest disadvantages are the complicated valve gear and the somewhat vulnerable exhaust turbo-blowers.

Whilst the two types are obviously competitive, the two power strokes of the two-stroke engine to each one of the four-stroke engine would appear to make the former the main locomotive power unit of the future, wherever the maximum power reliably available from the smallest weight is the main criterion. This trend in its favour is increasingly exemplified by the attention being given to the two-stroke cycle by engine makers who have in the past been interested only in four-stroke cycles.

Both types are however at the moment available, with power/weight ratios and other characteristics making them eminently suitable for reliable Diesel-electric locomotive use with upwards of 10000 hours' service between general engine overhauls.

Diesel engines in powers of up to 2400 h.p., and even above, are readily available for locomotives.

The Main Generator

The main electric generator is almost invariably a single-bearing machine whose stator is spigoted on the Diesel engine and whose armature is also spigoted on a suitable crankshaft flange so that the engine crankshaft bearing supports half the armature weight. The main generator drives an auxiliary generator, either direct coupled or through gears or belts and pulleys, which supplies low-tension power for the numerous auxiliary services in the locomotive. The generator is ideally suited to occasional use as a motor, and fed from a battery is generally used in this way to start the Diesel engine.

The complete engine generator set may be mounted in the locomotive at various points, generally with some resilient packing, or it may have the popular three-point suspension with one resilient support under the engine and two under the generator. Both systems have their advantages but the three-point suspension is most favoured since the assembly then requires no careful fitting, and irregularities and movement in the locomotive structure cannot distort the engine and impair the all-important crankshaft bearing alignment.

Traction Motors

For Diesel-electric locomotives simple robust d.c. axle-hung nose-suspended traction motors are universally used. They give the utmost satisfaction and are in general somewhat smaller and more simple than their straight-electric counterparts, since they have less insulation stress and are not subject to line voltage surges. Again they are almost universally forced-draught ventilated by a fan or fans in the locomotive body. The generator voltage is usually 600–900 volts and the various traction motors are preferably fed in parallel from the generator, although in some locomotives, for special reasons, two traction motors are permanently connected in series.

Electric Control Gear

This again is very simple and robust, the self-contained power generation on the locomotive making its duty much easier than that of its straight-electric-traction counterpart. It is ideally suited to multiple-unit operation where any number of locomotives up to say four are mechanically and electrically coupled together and simultaneously controlled by the same driver.

Locomotive Mechanical Parts

The mechanical parts are almost identical with those of the corresponding straight-electric locomotive and generally a double-bogie construction is used with four or six axles, which gives operating and riding characteristics over the whole speed range that are very attractive.

There are, however, special locomotives, particularly those having low axle loads of the order of 10 tons, where power-bogie construction is not the most economical; many such successful types are in operation.

Evolution

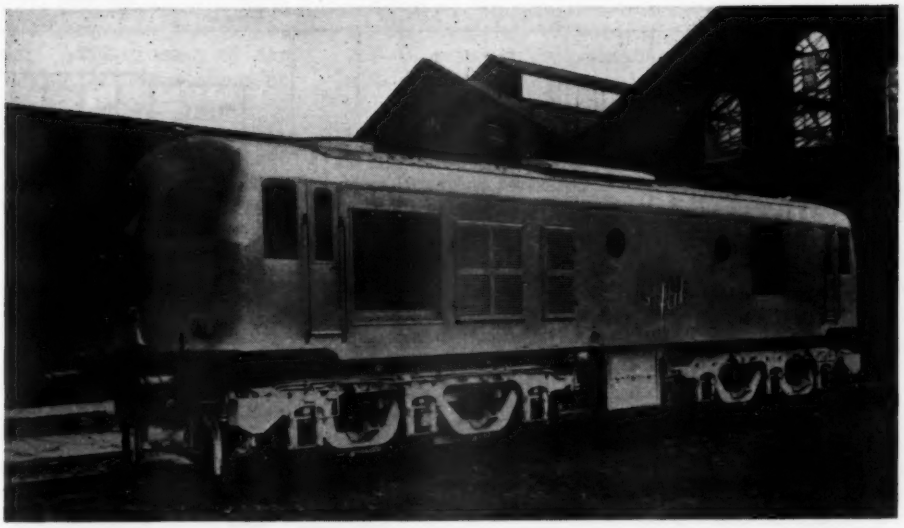
Whilst the present-day Diesel-electric locomotive differs little from its pre-war counterpart in external appearance, it has in fact evolved greatly in many ways.

The Diesel engine horse-power, for a given size and weight of engine, is often as much as 33% greater.

Improved design and insulating materials have enabled greater performance of electrical transmission with less weight to be obtained. Improved insulating materials such as silicones have been of great assistance in permitting higher operating temperatures to be used.

In the early days of the Diesel-electric locomotive it was often difficult to produce a locomotive with sufficient horse-power and continuous tractive-effort rating within the permitted locomotive weight, but through steady evolution, this is less and less a limiting feature, to the extent that sometimes a locomotive has its weight increased above that dictated by the minimum construction figure to allow greater maximum tractive efforts to be used.

Throughout the whole of this development period, alternative Diesel-hydraulic systems of transmission have been advocated and fostered in some countries, but in sizes suitable for main lines they have failed to secure any general adoption, and their high cost, lack of



3 *A 1 200 h.p. Diesel-electric mixed-traffic locomotive*

flexibility and proven mechanical background, and their greater fuel consumption for any given job, appear adequate reasons for this.

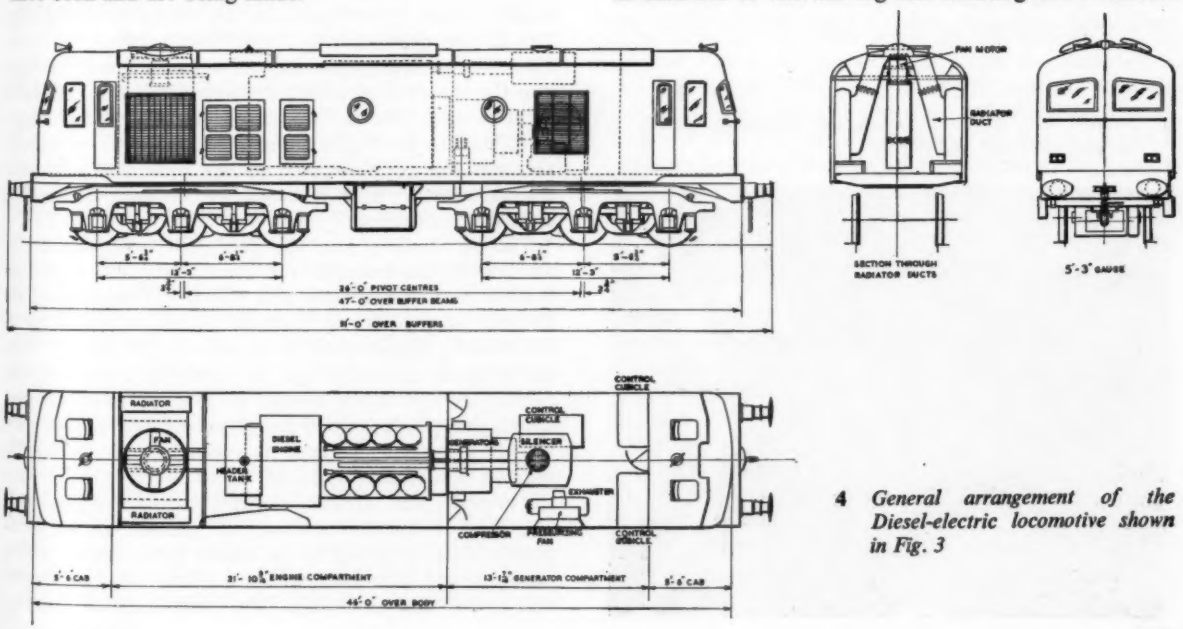
As against the numerous types of locomotive normally needed for its different classes of traffic by a railway using most other forms of motive power, with Diesel-electric traction it is possible to have a single type of locomotive for all classes of traffic, heavier and faster trains often being operated by a number of multiple units with a single driver.

A Typical Diesel-Electric Locomotive

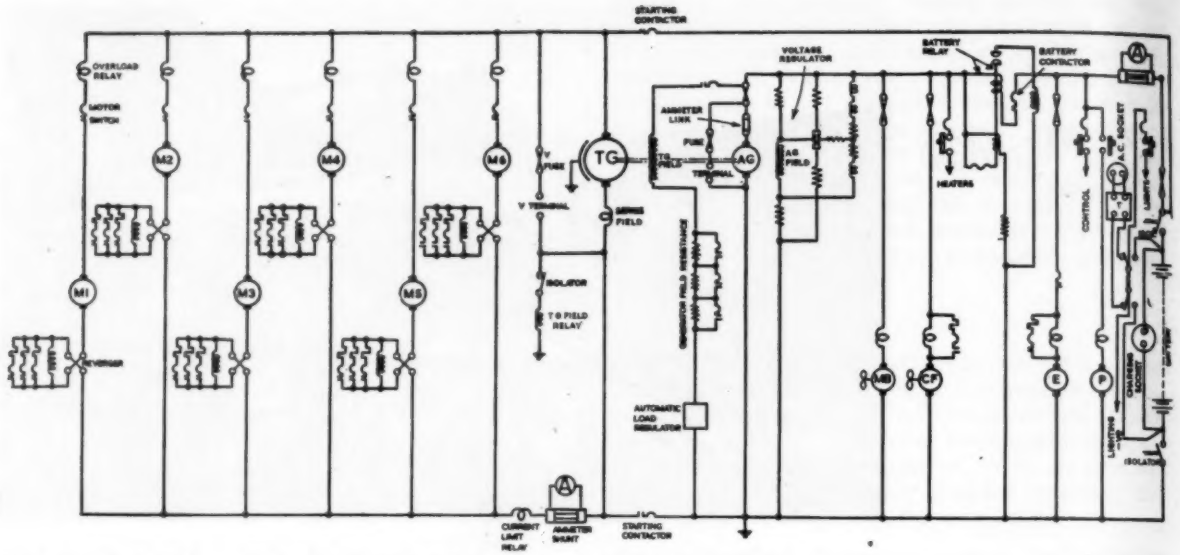
There follows a short description of a typical modern Diesel-electric locomotive of which considerable numbers have been and are being made.

Fig. 3 is a photograph of this 1 200 h.p. 85-ton locomotive and Fig. 4 is a general drawing from which the positions of the various components are readily seen. The locomotive is of the conventional swing-bolster double-bogie six-axle six-motor type capable of a maximum speed of 75 m.p.h. and having a maximum starting tractive effort of 62 000 lb and a continuous-rating tractive effort of 17 400 lb. The fuel tank, which is integral with the locomotive body underframe, has a capacity of 500 gallons, on which it can normally operate for something over 500 miles.

There is a driver's cab at each end, and, to facilitate single-man operation, two controller stations are provided in each cab so that driving and shunting can be carried



4 *General arrangement of the Diesel-electric locomotive shown in Fig. 3*



5 *Power and auxiliary circuit diagram of the Diesel-electric locomotive shown in Fig. 3*

A = Ammeter. P = Lubricating-oil priming pump. E = Exhauster.
AG = Auxiliary generator. T = Transformer. MB = Motor-blower.
CF = Cooler fan. TG = Traction generator. V = Voltmeter.

out from any one of four positions most suited to the particular conditions. During driving, it is quite unnecessary to leave the driver's cab, and in the event of the driver doing so or being incapacitated, the power is cut off and the train and locomotive brakes are automatically applied.

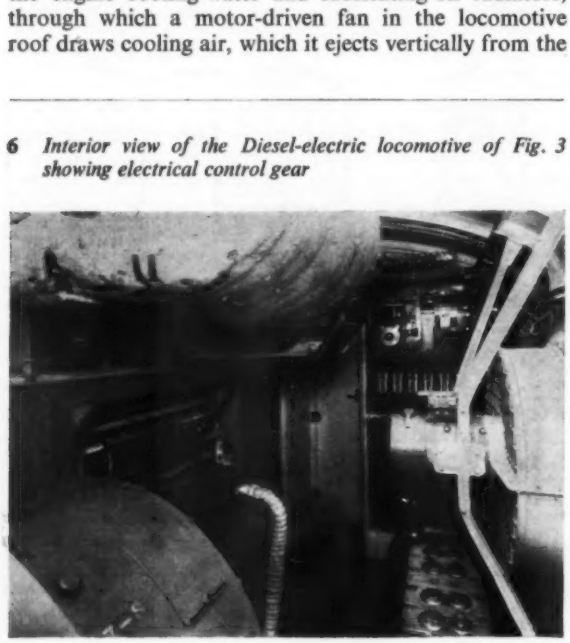
Behind the driver's cab on the left of Fig. 4 are the engine cooling-water and lubricating-oil radiators, through which a motor-driven fan in the locomotive roof draws cooling air, which it ejects vertically from the fan. Next comes the engine end of the engine generator set shown in Fig. 2, which weighs something over 20 tons and is carried on three flexible mounting points by the locomotive underframe. The engine combustion air is drawn in through the duct shown through air filters placed in the locomotive side wall.

It will be seen that there is a partition in the locomotive structure separating the generator section from the engine section of the body, and this allows the ventilating fan on the generator to draw clean cooling air from louvres in the locomotive outside wall and pass it through into the engine compartment, which keeps this compartment cool as the air passes on its way out through ventilators in the engine compartment. This arrangement prevents any oily vapour getting into the generator compartment, where it could be detrimental to the electrical equipment.

The air coming into the generator compartment is assisted by the motor-driven pressurizing fan shown in the locomotive side wall, and this forces ventilating air through ducts to the six traction motors on the bogies in addition to augmenting the generator cooling air flow set up by the generator fan. An important feature of this combined ventilating system is that at lower engine speeds and powers, when the generator may still be very heavily electrically loaded, its ventilating air caused by its own fan, which would fall away proportionally with the engine speed, actually falls away only marginally.

In this compartment there are located an air compressor directly driven by the engine generator set and a motor-driven exhauster which actuates the locomotive and train vacuum brakes. The three control cubicles

6 *Interior view of the Diesel-electric locomotive of Fig. 3 showing electrical control gear*



containing the electrical control gear are also shown in Fig. 6. On the locomotive underframe, lying between the two bogies, are two battery boxes containing the batteries mainly used for starting the Diesel engine by using the generator temporarily as a motor.

The 1 200 h.p. Diesel engine is of the two-stroke type having 8 cylinders of 10·5 in. bore and 13·5 in. stroke arranged in two banks of four cylinders in vee formation and produces its full power at a speed of 625 r.p.m. A Roots scavenge blower is mechanically driven by the engine and is situated at the end remote from the generator.

The traction generator is an eight-pole machine with interpoles; it is separately excited and counter-compounded and the series winding is used for starting the engine. Carried on the generator shaft is an auxiliary generator supplying power at 110 volts for the various locomotive auxiliary services.

Each of the six traction motors is a four-pole series-wound machine of the axle-hung nose-suspended type which drives the axle through a single-reduction spur gear.

Referring to Fig. 1, the automatic output control system maintains, on each of the full-power notches 4 to 10, substantially constant engine speed and power with rising locomotive speed. It does this by gradually increasing the separate excitation of the generator, and then, after full generator excitation has been reached, by progressively weakening the traction motor series fields. This functions by taking a signal from a hydraulic pilot valve connected to the engine governor fuel lever which actuates a servo-motor-driven regulator.

Fig. 5 shows the main power and auxiliary circuit diagram, reference to which will assist in understanding many of the foregoing descriptions. Fig. 6 shows the electrical control equipment installed in the locomotive, the cubicle protective covers having been removed to reveal it.

For the sake of continuity all the illustrations used in this review relate specifically to the 1 200 h.p. 85-ton Diesel-electric locomotive described above, and it should be remembered that on other types of locomotive somewhat different constructions, circuits and equipment are successfully used.

MORE HOPE FOR THE ARTHRITIC

HOW THE BRITISH RHEUMATIC ASSOCIATION WILL HELP MEMBERS

The Secretary has been asked by the Secretary of the British Rheumatic Association to bring the Association's services to the attention of members, and the following note has been written by one of the officers of the Association for this purpose. The Association has a particular interest in cases of rheumatoid arthritis among professional and technical persons employed in industry, since it is very conscious of the effects of this illness on production, but men and women from all walks of life suffering from any form of rheumatism may be accepted as patients.

One of the main human problems in industry is the amount of absenteeism and premature retirement occasioned by rheumatism, particularly in its more crippling form, rheumatoid arthritis. According to Professor Sir Henry Cohen, there are in the United Kingdom 500000 sufferers from this complaint, which, if not properly treated, can lead to permanent crippling.

Against this dark picture of the incidence and effects of rheumatoid arthritis can be placed the brighter light of present-day knowledge on the subject. It has been estimated that nowadays 60–80% of cases can be cured or checked ***if diagnosed and treated in time.***

Unfortunately this timely diagnosis and treatment are, in many cases, not effected for a variety of reasons. First the patient may not know how effective diagnosis and treatment can be obtained and may leave it until too late. Secondly, few hospitals have proper rheumatism departments. Those which have often lack the necessary bed space so that the time lag between recommendation for in-patient treatment and admission may be as long as 9–12 months. This means extra months of pain for the sufferer, of worry for his family and of sporadic or continuous absenteeism for his employer. But, worst of all, this delay means that his diagnosis and treatment are no longer ***in time*** and gravely prejudices the outcome of his case.

The British Rheumatic Association, under its President, Lord Nuffield, realizing the effect that rheumatoid arthritis has on industrial production, has taken immediate steps to close this gap between medical knowledge and the sufferer, and to combat this serious delay.

With the goodwill of the Ministry of Health it has opened a hostel for rheumatic sufferers at Bracken Hill House, Northwood, Middlesex, where its primary aim is to deal with ***early*** cases of rheumatoid arthritis in industry. Bracken Hill House is a modern mansion standing in its own spacious grounds. It is centrally heated, beautifully appointed, and formerly belonged to a millionaire. Here patients are accommodated without delay and are transported daily by car and ambulance to Mount Vernon Hospital (less than two miles away), where they receive expert diagnosis and treatment in the Hospital's Rheumatism Department. The diagnosis and treatment

Bracken Hill House, a comfortable and inviting mansion where rheumatic patients are accommodated for treatment at a nearby hospital

are free, and the charge for accommodation varies between £5 5s. and £9 9s. a week, the latter being the charge for a single room. These amounts, it will be generally conceded, compare very favourably with the charges payable in a nursing home or a private hospital ward whose accommodation and amenities are approximately equal to those of the hostel.

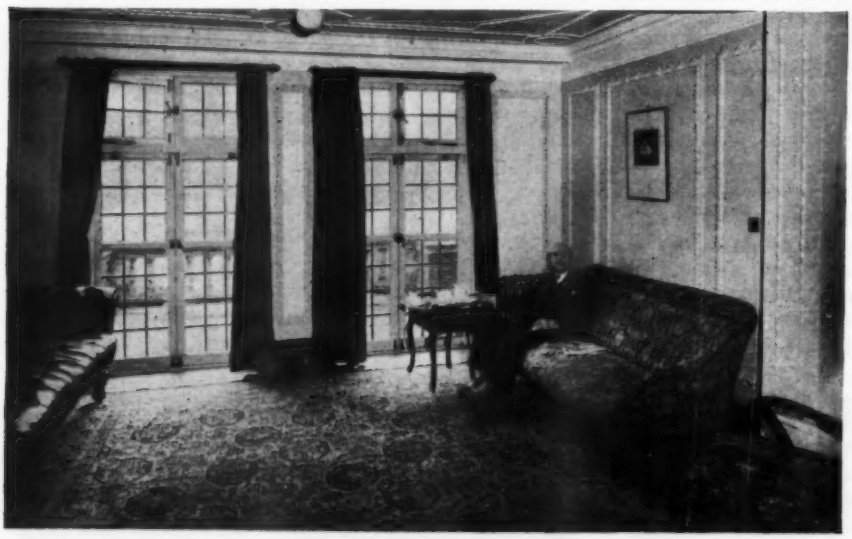
Through the co-operation of the local Regional Hospital Board cases can be accepted from any Region in the United Kingdom, with the stipulation that they must be early cases. The normal stay at the hostel is 6–8 weeks, and many successful results have been reported.

The comparatively low charges for accommodation at the hostel are made possible largely by the support of industry. The hostel, in its turn, seeks to assist industry, including the primary professions that serve it. For this reason it wishes to make its service known to members of The Institution.

In addition to Bracken Hill House, the British Rheumatic Association runs a welfare service for all sufferers from all forms of rheumatism in their early or chronic stages. Assistance is given in the form of transport, home help, visiting, etc., and the Association advises about facilities for treatment, home employment, light employment, holiday accommodation, etc.

Should any member of The Institution require any further particulars for himself or his family about the hostel, or any help or advice (free of charge), inquiries are welcomed by The Secretary, British Rheumatic Association, 11 Beaumont Street, London, W.1.

Electrical engineers serve the community. The British Rheumatic Association would like to serve them.



A patient at Bracken Hill House has tea in the lounge

The Betatron

K. PHILLIPS, M.Sc., ASSOCIATE MEMBER

The exploration of atomic nuclei has stimulated the development of particle accelerators. The one described in this article is used for the production of fast electrons and penetrating X-rays, and has found valuable applications in the treatment of cancer. The author, who is with Metropolitan-Vickers Electrical Co., was engaged for some time on the construction of a new betatron for the Christie Cancer Hospital and Holt Radium Institute, Manchester. The article is based on a paper (No. 1886) entitled 'A 20 MeV Betatron for X-Ray Therapy', written jointly by the author, Mr. D. Major, B.Sc., B.A., and Mr. F. R. Perry, M.Sc.Tech., Member, which was published in Part A of the Proceedings in December, 1955.

Introduction

WITHIN recent years there has been a rapid development of new methods of accelerating electrons to very high energies. The main impetus for this has been the need for high-energy electrons and X-rays in experimental nuclear physics, where they may be used to investigate the structure of the atomic nucleus. Furthermore, when these high-velocity electrons approach an atom they are deflected and produce high-energy X-rays, which can penetrate many inches of steel, and are used to examine thick metal castings for flaws. High-energy electrons and penetrating X-rays may also be used to treat deep-seated cancer, and, although there is unlikely to be any significant difference in the response of the tumour compared with the more conventional X-rays at present in use, the more penetrating rays produce a more localized effect which reduces relative damage to healthy tissues.

An obvious method of accelerating charged particles is to use a high-voltage source. This was done by Cockcroft and Walton (1930) with their high-tension generator. This type of equipment has become standard for some low-energy nuclear experiments in which protons (hydrogen nuclei) are accelerated to an energy of a few hundred kilovolts. Another type of electrostatic machine was developed by Van de Graaff in 1931, but this equipment is limited by insulation difficulties. However, these types of generator are still usefully employed in some fields of nuclear physics and for therapeutic purposes, but they are limited to energies below 5 MeV.

The insulation difficulties can be avoided in an induction accelerator. This was originally suggested by Slepian as early as 1922 and the principles of operation were formulated by Wideroe in 1928, but it was not until 1941 that Kerst successfully made a 2·3 MeV induction accelerator, or *betatron*, as it is called. Many higher-energy betatrons are now in operation in various research and therapeutic institutes throughout the world, and an accelerator of 300 MeV has been recently constructed.

Principle of the Betatron

In a betatron electrons are accelerated by the first quarter-cycle of an alternating magnetic field. They travel in an evacuated toroidal chamber, or *doughnut*, supported between the poles of an electromagnet. They are injected into the chamber when the magnetic field is low, and as the flux through the electron orbit increases, the electrons experience a tangential force. Their gain in energy (in electron-volts) per revolution is equal to the voltage that would be induced in a loop of wire placed at the orbit position. The betatron can be considered basically as a power transformer in which the secondary winding is replaced by an electron orbit. In order to keep the electrons in a stable orbit it is necessary to satisfy the following flux condition:

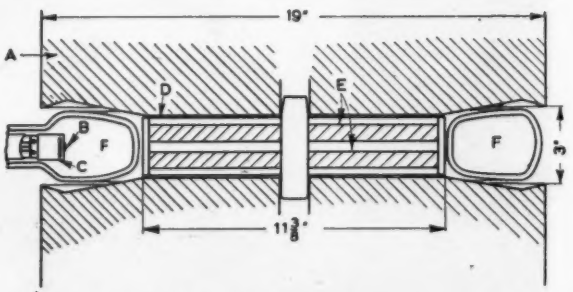
$$\frac{d\phi}{dt} = 2\pi R_0^2 \frac{dH_0}{dt}$$

where $d\phi/dt$ is the rate of change of flux linking the orbit, dH_0/dt is the rate of change of field strength at the orbit, and R_0 is the stable orbit radius. That is to say, the rate of change of the magnetic field at the orbit must be equal to half the rate of change of the mean magnetic flux per unit area linking the orbit.

Another important condition for successful betatron operation is that the magnetic field should produce focusing of the electron beam. This is achieved both horizontally and vertically by a magnetic guide field H such that the vertical component is given by:

$$H_z = H\left(\frac{R_0}{R}\right)^n$$

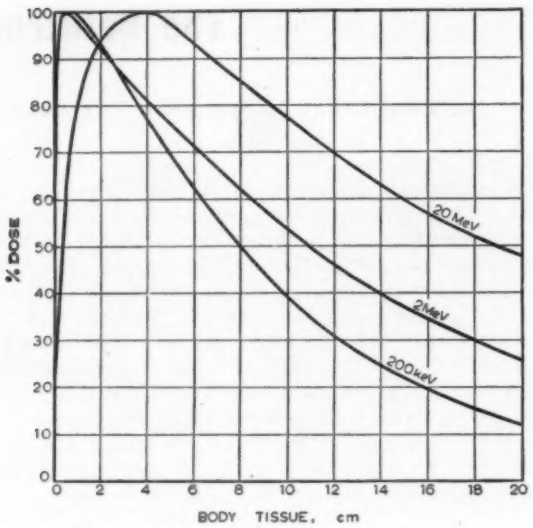
where $0 < n < 1$ and R is the radial position of the electron. The value of the index n generally lies between 0·5 and 0·75. Fig. 1, a cross-sectional view of the magnet



1 *Cross-section of a typical betatron magnet*

The poles are shaped to give correct variation of magnetic field with radius.

A. Top pole of magnet.
B. Platinum target.
C. Electron gun.
D. Centre piece.
E. Steel laminations.
F. Vacuum or doughnut.



2 *Depth/dose curves for different radiation energies*

The low-energy X-rays have a maximum dose just below the skin whilst the higher-energy X-rays have a maximum at correspondingly greater depths according to their energy.

and doughnut, shows the relatively small space occupied by the electron orbit, and also the shape of the pole pieces required to produce the focusing conditions. The successful injection of electrons onto a stable orbit is difficult, and has been the subject of considerable investigation, but the process is not yet thoroughly understood.

The electron gun projects radially into the vacuum chamber and injects electrons tangentially onto the stable orbit. The frequency of radial oscillations associated with the focusing forces is equal to $(1 - n)^{\frac{1}{2}}$ times the orbital frequency. After a number of revolutions of the electron beam around the toroid these oscillations cause the electrons to approach the gun. In order to prevent the gun intercepting the electron beam it is necessary to make it small. Fortunately, however, there is some mechanism, which is not fully understood, which damps these oscillations and causes the electrons to miss the injector.

When the electrons have been accelerated up to maximum energy the orbit is expanded by passing a high-current pulse through two coils above and below the doughnut. The electrons then strike a thin metal target, usually mounted on the anode of the electron gun, and produce a narrow conical beam of X-rays which emerges in the same direction as that of the electrons before striking the target. A continuous X-ray spectrum is produced with a maximum energy almost equal to the energy of the accelerated electrons.

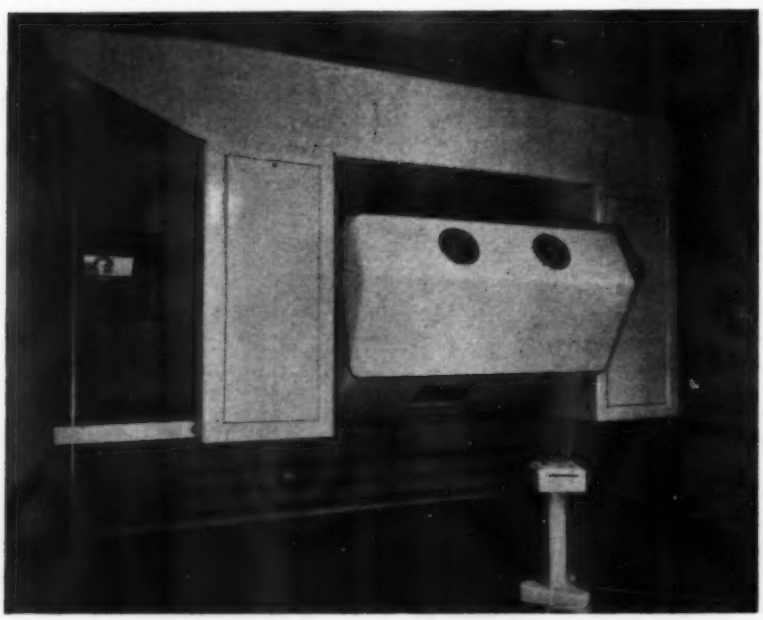
Uses of the Betatron

A betatron is an invaluable instrument for nuclear-physics research since not only can the high-energy X-rays split the atomic nucleus (*photo-disintegration*) but the high-velocity electrons can be used as a probe to determine the shape of the nucleus. The usefulness of the betatron lies in the fact that the energy of the electrons can be controlled to within 1 part in 1000 without any loss in the X-ray yield. Consequently an accurate study of nuclear energy levels can be made.

Another major use of the betatron is in X-ray therapy. When high-energy X-rays penetrate human tissue the ionization increases with depth, reaches a maximum and then slowly declines. The position of this maximum is about 4 cm below the skin for 20 MeV X-rays, whilst for 2 MeV X-rays it is approximately 0·5 cm and for 200 keV X-rays the most intense ionization occurs just below the skin. This is shown in the depth/dose curves in Fig. 2. By using high-energy X-rays, therefore, it is possible to deliver a lethal dose to a tumour with less damage to the healthy tissue. However, it does not seem likely that X-rays of very much higher energy will be used for cancer treatment, since at energies above, say, 50 MeV damage to the bone increases rapidly. With con-

3 *The 20 MeV betatron at Christie Hospital, Manchester*

The magnet is slightly tilted, the position being controlled from the small pedestal in the foreground. A periscope, through which the radiographer can be seen, is used to observe the patient through the 3 ft-thick protective wall.



ventional X-rays one of the limiting factors is the delivery of a destructive dose to the skin, producing burns and erythema. This is not the case with megavolt X-rays since the skin dose is merely a fraction of the maximum dose given to a tumour within the body.

The author has been closely concerned with the installation of a new betatron for therapeutic purposes at the Christie Hospital, Manchester. This instrument is shown in Fig. 3. The magnet, which weighs 7½ tons, can be rotated through 120° so that the X-ray beam can be projected in any direction from 15° above the horizontal to 15° past the vertical. The framework in which the magnet is supported can be raised and lowered a distance of 7 ft. Radiation from the machine is directed onto a patient through a collimator, into which different treatment cones are fitted according to the field shape required. These cones are made of 12-inch-thick lead and are so shaped that they produce a flat, uniform field of X-rays. The X-ray beam may be adjusted by four controls, two of which are normally pre-set. The collimated X-ray yield of the machine is about 50 röntgens/min at 1 m from the target. This reduces treatment times to about four or five minutes per patient.

CORRESPONDENCE

IMPROVEMENTS IN RADIOTELEGRAPH RECEIVERS

From H. B. LAW, B.SC.TECH., ASSOCIATE MEMBER

Long-distance radiocommunication in the 4–30 Mc/s band is affected by ionospheric disturbances, fading, noise, interference and atmospherics, and all too often conditions deteriorate so far that channels become unserviceable. Important point-to-point telegraph channels are commonly of the direct-printing synchronous type, in which deteriorating conditions manifest themselves as increasingly frequent errors in the printed copy; a good system will maintain an acceptable error rate for as long as possible. Recent work has shown that conventional methods of frequency-shift telegraphy (f.s.t.), which are now very fashionable, leave something to be desired.

In a normal two-condition f.s.t. system two frequencies, usually differing by a few hundred cycles per second, are allocated to the 'mark' and 'space' conditions, and demodulation in the receiver is by the conventional f.m. technique using a limiter and a frequency discriminator. The receiver is liable to fail whenever either the mark or the space signal fades into the noise. The fading of h.f. signals is very often frequency selective and in these circumstances the mark and space signals normally fade differently. Since the full message is available on both frequencies errors need arise only on the comparatively rare occasions when the signals on both frequencies fade simultaneously. If, for example, strong mark elements precede and follow a weak and indeterminate element this can be identified as a space. Thus a frequency-diversity effect is available but the conventional receiver fails to profit by it.

The receiver problem may be considered in terms of the effective use of information. The ideal receiver would make use of all the available information about the waveforms and amplitudes of undistorted signals, the *a priori* probabilities of receiving mark and space signals, the nature of disturbances to be expected, etc. It can be defined as the receiver that interprets signals with the lowest possible liability to error. So far as disturbance by white Gaussian noise is concerned, analysis based on the methods of Woodward and Davies* leads to a mathematical specification for the demodulation process of the ideal diversity receiver. Separate diversity branches are used for mark and space signals, and the noise-distorted signals received in each branch are correlated with perfect local signals. Branch outputs are weighted according to signal energy and then combined. The absence of a signal in a branch is of significance equal to its presence, the interpretations being of course of opposite sense in the two conditions. This mathematical specification has been used as a guide in the design of an experimental demodulation unit, which is little more complex than the corresponding parts of a conventional receiver. Simplifying departures from the specification include neglect of the carrier phase, correlation being by means of linear-build-up filters, and diversity combination on a voltage rather than an energy basis.

The calculated error liability of the ideal receiver provides a basis for the assessment of practical equipment in terms of the ratio of the signal energies required to produce a given error rate, the noise energies being the same. This measure of imperfection seems likely to be important and it is tentatively suggested that it should be called the *demodulation factor* or *demodulation noise factor*. Laboratory tests of the experimental equipment have shown that, despite the departures from the specification, the noisy-signal performance is close to the ideal, a demodulation factor of 3dB being obtained on fading signals at a signalling speed of 100 bauds. Under favourable conditions of selective fading the frequency-diversity gains may reach 15dB and 6dB, in single-aerial and dual-space-diversity receivers respectively, at an element error rate of 1 in 10^4.

Laboratory comparisons with a high-grade dual-space-diversity receiver of the conventional type suggest that the new demodulation technique may give inherently better demodulation factors even under flat-fading conditions; in effect the receiver bandwidth is narrowed to the limit. Further comparisons have been made in field trials, using signals from Australia, and the very variable results may be summarized as showing a tenfold advantage in error rate in

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* WOODWARD, P. M., and DAVIES, I. L.: 'Information Theory and Inverse Probability in Telecommunications', *Proceedings I.E.E.*, Paper No. 1239 R, March 1952 (99, Part III, p. 37).

favour of the experimental unit at error rates of the order of 1 in 10^4. The variability of the results is attributed to the disturbance of the signals by atmospheric crashes and bursts of interference; further study is required.

Detailed papers on the work, which may well have applications outside long-distance radiotelegraphy, will be published in due course. This communication is published by permission of the Engineer-in-Chief of the Post Office.

THE THEORY OF DIMENSIONS

From L. YOUNG, M.A., ASSOCIATE MEMBER

I am grateful to Dr. F. T. Chapman for pointing out in his letter in the January *Journal* an error in my previous letter. The unit of solid angle in the M.K.S. rationalized system is the sphere; in the M.K.S. unrationalized system it is the steradian.

Dr. D. A. Bell's letter in the January *Journal* is a fair statement and requires no comment so long as only a single system of units is used. My approach was heuristic. Angle is at the root of the diversity of constants chosen for Maxwell's equations. This led me to the system explained in my last letter. The notion of angle dimension as an *operation* was subsidiary, although I feel this idea has still to be fully exploited.

I should like to show briefly, by giving two simple examples, how angle dimensions are put to work.

(i) Let it be required to find the ratio of the M.K.S. rationalized and unrationalized units of magnetic field. Taking charge Q as the electrical dimension, the full dimensions of magnetic field are $[L^{-1}T^{-1}QST]$. The required ratio is therefore as sphere is to steradian (since all the other units are the same), which is 4π.

(ii) Let it be given that the energy density of the electrostatic field in electrostatic units is $\boldsymbol{E}.\boldsymbol{D}/8\pi$. It is required to find the expression in M.K.S. rationalized units. The missing dimension is (S^{-1}). However $S = 4\pi$ in electrostatic units. Therefore the correct expression in all systems of units is $(\boldsymbol{E}.\boldsymbol{D}/8\pi) \times (4\pi/S)$, which is $\frac{1}{2}S^{-1}\boldsymbol{E}.\boldsymbol{D}$. In the M.K.S. rationalized system $S = 1$ and this reduces to $\frac{1}{2}\boldsymbol{E}.\boldsymbol{D}$.

A table of the numerical values of S and T, and the units of the two angles, in the six electrical systems of units commonly used is all that is needed to tackle any dimensional conversion problem.

The operational aspect of S and T in a dimensionally complete formula needs further investigation. So far I have not discovered a satisfactory approach.

ATTITUDES OF MIND

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A. R. COOPER

This article is a series of excerpts from a lecture given by Mr. Cooper, who is well known to many members, to seventeen Graduate and Student Sections in various parts of the country and to the Irish Branch of The Institution at Dublin during the last two years. The author has not used notes and all the lectures have consequently been different from each other, but this article presents the theme upon which they were based.

ANY man who has lived for fifty years or more is liable to suffer from attacks of garrulous reminiscence. I am no exception to the rule, and in this present instance I propose to consider some of those things which in retrospect appear to be significant in life. I see myself as a scout who has been sent by a team of youthful explorers to reconnoitre some twenty-five years ahead and who is now reporting back.

In thinking over my experiences I am forced to the conclusion that one of the most important things to any man is the attitude of mind with which he approaches the problems of his life. What he thinks can be much more important than what he actually does, for the quality of what he does may be affected by many things beyond his control, but his thoughts are his own. What he really is, is determined by the way he thinks. For this reason I propose to take, as my general theme, attitudes of mind, and to indicate so far as I am able the ways in which they can influence the future life of a young engineer, of say 25 to 30 years of age, who intends to live to some purpose.

If he plots on a time basis a curve of his self-esteem, he will probably find that it will rise to a peak at about thirty, fall gradually to the age of 40, and, if he is a good type, flatten out to a healthy and reasonably accurate low level from 45 onwards. This is as it should be, for humility is related to our confession of ignorance, and if we use a sphere to illustrate the sum-total of our knowledge we see that the surface area, which represents our contact with the unknown, increases as our total knowledge increases. In other words, healthy intellectual growth should lead to increasing humility, and any man who finds himself becoming more conceited as he grows older should begin looking for the cause of the trouble.

Promotion

Probably the dominating attitude of mind in our hypothetical young man is personal ambition. He sees himself, somewhere in the misty future, sitting in a managing director's chair, or riding in a large black shining car with obsequious minions striving anxiously to satisfy his slightest whims. He does not realize that the same mental picture hangs before the minds of almost all his contemporaries. Neither does he see the bottle of bismuth tablets in the top right-hand drawer of the mahogany desk.

Let us examine this situation in a little more detail.

Every large organized body of people, whether it is a government, an army or a business, is constructed in the form of a pyramid, with a chief executive at the top and large numbers of lower-level people at the bottom. Suppose we consider a business which has a President and three Vice-Presidents. Each of the three Vice-Presidents is consciously or subconsciously hoping that something will happen to the President. These sentiments are not necessarily unkind; they may even imply that the President ought to retire and get more real enjoyment out of life while he can—anything, in fact, which will get him out of the way and allow some younger, more virile, more progressive type to move up and run the business. But there are three Vice-Presidents and there would be only one vacancy. They may be the best Vice-Presidents in the world, but if they have all set their hearts on promotion two of them are going to be disappointed.

Below the three Vice-Presidents are eight Section Heads, all wanting to be Vice-Presidents, and here again, if promotion is to be the be all and end all, most of them are going to be disappointed. And so this process can continue right down the administrative pyramid, and competent hard-working conscientious men can become sour and bitter at their failure to climb higher, not realizing that the great majority are defeated by the simple mathematics of the situation. It follows that if all our hypothetical young men regard themselves as failures if they end up in anything lower than the managing director's chair there is going to be a lot of unhappiness around.

Let us look further at this matter of promotion. In order to obtain a bigger job a man must give proofs of his suitability. Many factors may be involved in addition to his technical competence; his manner, his appearance, even the way he dresses may be significant attributes. But even when all these variables are taken into account there is still one factor completely outside his control, and it may easily outshine all others. This factor is luck—just plain luck. The fact that he happened to be around at the time; that something good he did was noticed and something better done by someone else went unnoticed. There is generally no escape from this component, although some self-made men will tell you that a real go-getter will create his luck. Our hypothetical man—let us call him Bill Smith—will have to develop an attitude of mind, a philosophy if you like, which will take care of this situation if it arises, for if he becomes soured he will merely injure himself and probably damage his future prospects, for many an employer considers that the best time to judge a man is when he is suffering a disappointment.

Now, let us look at the problem of promotion from another angle. Charlie Jones is the best craftsman in the fitting shop. In fact he is so good that when the position of foreman becomes vacant Charlie becomes the automatic selection. But Charlie Jones the foreman turns out to be a complete failure. Although he was expert at controlling the work of his hands, he has not the slightest idea of how to control people. He cannot appreciate their differing personalities, he doesn't know when to be tough and when to give way, he finds that he has lost his old pals and does not know how to make new ones. Promotion was the worst possible thing both for Charlie Jones and for the firm.

Cases of a comparable nature can occur all the way up the administrative scale. People are made differently and are naturally adapted to different kinds of work. There are natural leaders and natural followers, people who thrive and grow with responsibility, others who wither and die under it. I think it was David Lloyd George who said that it would be a great help if men were like motor lorries and were stamped with the maximum loads they could safely carry.

All this leads me to the general conclusion that a man should have a healthy ambition which will drive him up to his right level—a level above which he would be miserably unhappy and unsure in the execution of his job, and below which he would feel that, in some degree, he had failed. To almost every man a time comes when he bumps his head against his promotional ceiling. It may come early or late in life, and if the situation is not taken

care of by his attitude of mind the savour of life can depart and mental rot can set in.

Success

Every man who makes progress in his profession is liable to find that there is very little applause for him on his way up. In the senior circles in which he arrives he is liable to be regarded as a presumptuous intruder for quite a long time, possibly until some other 'new boy' follows him, whilst the people he leaves behind and those he passes on the way up would not be human if they did not try to rationalize their own lack of progress by applying unflattering motives to his.

All this is part of the price which must be paid for what may be called 'success' or if you prefer it 'fulfilment'. There can be no looking back. The people who sneer when you make progress would be the first to sneer if you made none. The essential thing is to handle these situations with dignity and self-respect. Time is the only remedy for some complaints and one should not become soured by expecting results too quickly. This attitude of mind may appear to be cynically pessimistic, but I think it is necessary to be a realist in these matters because it can come as a great shock to discover for the first time that for no apparent reason one can be actively disliked. There is, of course, another side to this picture, for the very experiences which produce pain and disillusionment in some people can also reveal men of stature and great-heartedness who had previously gone unrecognized. Anything which is worth while rarely comes easily, and bitterness is more likely to be the lot of the man who looks for a comfortable passage than for one who sees reward only as the result of effort.

One of the greatest obstacles to any young man's progress is his fear of looking foolish. It prevents him from standing up and asking questions at technical meetings, it stops him from learning from those around him, it makes him refuse to make after-dinner speeches or to give lectures, for always there is the thought that he might dry up, that someone would laugh or that he might be unduly exposing his ignorance. Every man has to fight this battle alone, and if he continues to avoid the issue he will see men of less talent but greater personal courage climbing past him. It is easy to take refuge in slick phrases such as 'He's got the gift of the gab' or 'He's got a hide like a rhinocerous', but I think it is safe to say that, on average, any man who is able to express himself has had to win a difficult personal struggle and that in some cases it never ceases to be a struggle.

In the critical times of life it is usual to find that so far as human associations are concerned we are uncomfortably alone, and it is our ability to come to terms with ourselves during these periods which will largely determine the pattern of our future development. Emerson can often produce the right words for the occasion and the following is a quotation from his essay on 'Self Reliance':

> It is easy in the world to live after the world's opinion; it is easy in solitude to live after your own; but the great man is he who in the midst of the crowd keeps with perfect sweetness the independence of solitude.

There is nothing wrong in wanting to be successful. The very thought is a driving force and a co-ordinator of resources—it can give point to one's existence. The danger lies in seeing success only in certain dimensions such as wealth or fame or power. All these dimensions are relative and the success of the few is made possible only by the failure of the many. The only healthy form of ambition, as I see it, is to aim to live successfully. When this becomes the end in view men are no longer in conflict and the labourer has the same opportunity of reaching his goal as the statesman, the doctor or the company director. This theme, as you will have guessed, is a hobby-horse of mine, but it has always been a surprise to me that men are prepared to learn about everything except how to live their lives. Work is regarded as an end instead of as a means to an end, and the evolutionary trend is likely to produce either a race of laborious insects or a battery of calculating machines.

Personal Relationships

One of the problems which will almost always beset our hypothetical Bill Smith is that of working with other people. In business life they fall into three classes, those immediately above him, those at his own level and those who are his juniors. Whatever his position in the business hierarchy, these relationships will have to be dealt with. Their impact on him can be so strong and so immediate that they can be responsible for making or destroying the happiness of his working life. Bill Smith will inevitably develop towards these people certain attitudes of mind and if we examine them in their meanest possible interpretations we can establish a datum from which any change must be an improvement.

Let us call Bill Smith's boss A, his juniors C, and those at the same level B. What are Bill's meanest thoughts about his boss; in other words, what is the datum level of his A relationship?

The boss is a bad leader, he lacks courage, he cannot delegate, he has favourites, he steals credit and never appreciates what is done for him. The B relationship indicates that these men are vulgar exhibitionists, thrusters, toadies, self-seekers and not good team men. And C, the junior, is aggressive, immature, frivolous, unreliable. He is not fit to carry responsibility, is impetuous and lacks thoroughness in his work. He is not a good team man.

This list should be regarded as a minimum.

There are two merits in this exercise. First, a suppressed emotion, especially one of which we are not particularly proud, can often be dissipated merely by putting it in writing. Secondly, if Bill Smith wishes to know how he stands with his contemporaries, he may do worse than transpose the relationships. In other words, the chances are that the junior will think about Bill as Bill thinks about his boss, that the boss will think about Bill as Bill thinks about his junior, and that what Bill thinks about

his equals will be reciprocated. There is no need for pessimistic introspection to follow this analysis, but Bill may well ask himself occasionally whether if all these criticisms were laid against him one or two of them may not be true.

A traveller accosted a stranger and asked, 'What sort of people are they in the next village?'

'What were they like in the village you left?' asked the stranger.

'Delightful, I thoroughly enjoyed meeting them.'

'That', said the stranger, 'is exactly what they are like in the next village.'

Another traveller accosted the same stranger with the same question, and received the same question in reply.

'Oh,' said the traveller, 'they were dreadful types, I was glad to get away from them.'

'That', said the stranger, 'is exactly what they are like in the next village.'

The Second Think

As a rule I am all in favour of quick decisions; they allow action to flow and in the great majority of cases they are likely to be as wise as if they had been referred back and forth and generally mulled over for weeks or months. This rule is often likely to be unsuitable, however, when it is applied to dealing with people, and more especially with people who are being disciplined.

In cases of this nature the situation normally benefits from a second think. A poor snooker player is a 'first think' man. He is completely engrossed in the business of potting a red ball. If this operation happens to be successful he then looks round the table in the hope that a coloured ball may be somewhere in line for his next shot. The 'second think' player, while potting the red, is thinking how best he can combine this operation with leaving his own white ball in line with a selected colour for his next shot. His mind, in other words, is not dominated by the immediate situation but looks beyond it before taking action.

When disciplinary action is being carried out the immediate situation is usually one in which the employer is irritated by the negligence or wilful wrongdoing of an employee. The 'first think' approach is to punish the man, partly in the hope that it will deter him from doing the same thing again and partly because it helps to dissipate the anger of the employer.

The 'second think' approach is for the employer to look beyond the immediate situation and to discover, if he can, what it was that caused the man to behave in this particular way. This approach—when it can be applied—has two main advantages: first, it dissipates quite harmlessly the initial surge of anger by deflecting the mind of the employer away from the initial irritation. He finds himself concentrating on what might almost be a clinical problem—the tracing of emotional end products back to their root causes. If he can achieve this attitude of mind he will find it almost impossible to feel angry at the same time and his judgment will be governed by reason rather than emotion. The second advantage of this method is that it is more likely to produce a fair and lasting solution to the problem.

I have known cases in which kindly, well-intentioned men have made cruel and totally unjust decisions, not because they were inherently vicious people but merely because they did not think far enough into a situation. I have known other cases in which the 'second think' has resulted in some man being fitted into more suitable employment to the benefit of himself and the firm.

This 'second think' technique can often be usefully applied upwards as well as downwards in the administrative hierarchy. The domineering bullying boss becomes much less of a burden if we try to discover what makes him behave that way. If we observe that he suffers from blood pressure or ulcers, or if he is bullied to death at home by an aggressive little wife, his behaviour can be rationalized and more easily tolerated. It is also possible that we may discover in our researches that we were largely the cause of both the blood pressure and the ulcers, and that we were merely getting the sort of boss we deserved.

The Impact of the Job

Another attitude of mind which has always been of interest to me is a man's attitude towards his work. In the old days there was a person-to-person relationship in the job, and just as men tend to become rather like their dogs, so a man and his workmates tended to develop those qualities which they had in common.

With increased mechanization the relationship is tending to disappear, and in the extreme case in which a man finds that his sole companion during his working hours is a machine he will tend to become like a machine —unless he recognizes the danger and takes the necessary avoiding action. What, then, can our near automaton do in order to retain a healthy humanistic attitude of mind? Two things come to my mind, the first is connected with his job and the second with himself.

So far as the job is concerned I think it will help if Bill Smith makes it a conscious exercise from time to time to trace the impact, on the lives of other people, of the work he is doing. If he is working on a turbo-alternator, the thinking should not stop at the test run or the commissioning but at the mental picture of light, heat and power in the home, the office and the factory, and in the realization that because of what he is doing a certain number of people will be able to live more abundantly.

The second corrective, the one which a man applies to himself, I see as an organized escape route from mechanization. I suggest that he should try to cultivate spare-time activities in which measurement cannot intrude. Things like literature, music and the arts come to mind, in which every man can pursue the infinite in his own way, with the comforting knowledge that science cannot define what is good in literature or beautiful in art, and that even the best critics can be relied on to disagree. I feel that golf should be most definitely

included in this list of activities for although there is a theory that the golfer plays against bogey, which has been measured, he plays in fact against himself and all the kinks and inhibitions which go to make him the immeasurable hazard that he is.

Craftsmanship

Craftsmanship is much less in evidence than it was a generation or so ago and although this is largely due to the adoption of the mass-production technique, I think it is also due in some degree to a different mental approach to the job in hand. High-quality work of any kind can be produced only by intense concentration. A craftsman or an artist must think partly of what he is doing at the moment and partly of what he is trying to do as a whole. The increased tempo of modern living and the urge for quick results will tend to make him think more of the finished creation and less of the actual hammer blow or brush stroke he is making. The mental picture I have of the old craftsman is one in which about 90% of his mind is concentrated on the actual saw cut or turning operation he is doing, with a background of 10% correlating this work with the finished article. He sees an accumulation of perfect actions producing a perfect end product. The present tendency is for these percentages to be reversed with the result that speed, which dominates the process, causes the workman to think most of the time about the finished article and far too little about the individual acts he is performing. Thus we are likely to get work which may function but which lacks perfection —the badly fitted key, the poorly bedded bearing, the alignment which is not perfect but which is near enough. I think that this situation could be improved if, in teaching craft work to our students, we could inculcate some knowledge of how to think about a job.

The ability to concentrate can be improved by practice, and by the sort of practice which can be slipped in at odd moments. It can be an exercise in mental control and can take the form in which the student decides to think for as long as possible exclusively about any one thing—an inkpot for example. He will find that although he begins by thinking about the inkpot very intensively, irrelevant and distracting thoughts will begin to creep in. He will have to push them out and come back to his inkpot time and time again, but eventually he will discover, if he is sufficiently patient and strong-willed, that he will be able to take charge of the mental situation and hold any image clearly and separately for as long as he wishes. He can proceed from this condition to one in which he can hold the mental image while distracting conversation is going on around him or while a radio programme or even two different radio programmes are playing within earshot. The next phase can include the working out of complicated and then more complicated problems with the same disturbances impinging upon him. A fifteen-minute exercise once a week on these lines might be slipped into the educational curriculum with advantage and if it did no more than enable the student to do his home-work in a houseful of squalling children, it would not have been wasted.

Management

Many of you will undoubtedly become managers of labour, and some day you may well have to control factories of your own. I mention this subject because of an idea I hold that any employer of labour is inevitably responsible for two products. One is the article or commodity which the firm is manufacturing for the customer, the other is the man he is producing in his factory. The existence of this second product and the responsibility for its quality is all too rarely recognized, but it should be obvious that any man who spends the greater part of his waking life in a factory cannot remain unaffected by its conditions. He will be bigger or smaller, happier or less happy, healthier or less healthy, wiser or less wise because of his experience in this environment, for nothing in nature remains static over the years. The factory must produce a reasonably high-grade article for the customer or it would soon be out of business; this relationship is obvious or should be obvious to every man on the job. We know from our experience that a factory which is concerned only with the production of high-grade materials might at the same time be producing low-grade men. Let us suppose, however, that we have a firm making high-grade cables, which also recognizes its responsibility for producing high-grade men. If we change the emphasis and regard it essentially as an organization for producing high-grade men and as one which also produces electric cables we cannot lose, for although a low-grade man might in certain circumstances be made to make a high-grade cable, a high-grade man, by definition, would never make a low-grade cable.

I have exaggerated this argument in order that at least some of its emphasis will be retained, but I think that in its essentials it represents an attitude of mind which must ultimately prevail if men and management are to work together for the common good.

Conclusion

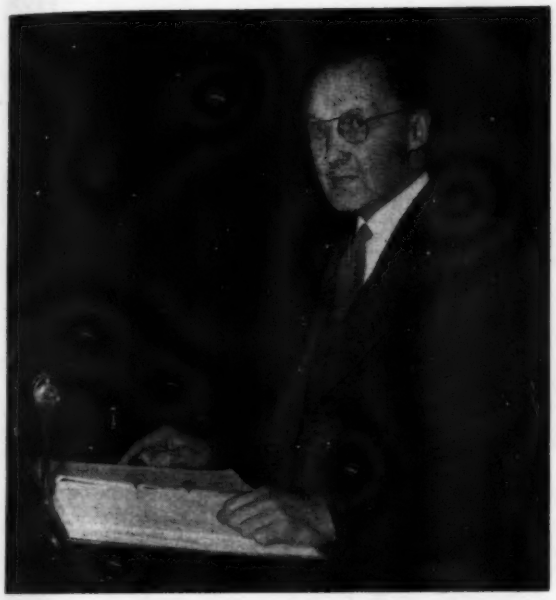
Finally, there is the need for retaining, as a basic attitude of mind, a healthy assessment of one's place in the scheme of things. I see a young well-trained engineer as a newly minted coin which is being put into circulation. One side of the coin represents his education and technical knowledge and it is bright and shining as it should be, for experts have been busily engaged on polishing it for some ten to fifteen years. The other side of the coin represents the sort of fellow he is, and here he starts level with everybody else, from the man who sweeps the shop-floor up to the managing director. In spite of his accumulated knowledge he might still be mean and selfish, narrow and intolerant, and inferior in many ways to some of the humblest people around him, and it is often the case that his future in the world of men will be judged much more on these things than on the academic qualifications he has acquired during his training.

HOME EVENTS

LONDON

The Faraday Lecture

Mr. B. L. Metcalf presented his Faraday Lecture *Coal Mining Electrically* at the Central Hall, Westminster, on the evening of the 15th February, before an audience totalling some 1200, of whom the larger proportion were non-members. Members of the National Coal Board were present as guests of The Institution.



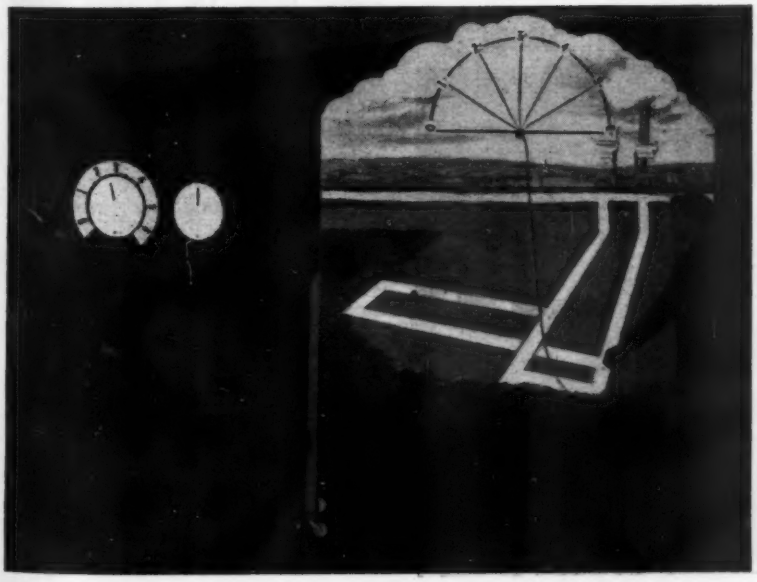
1 *Mr. Metcalf delivering this year's Faraday Lecture*

Sir George Nelson introduced Mr. Metcalf, who opened his lecture with a demonstration of the Davy lamp, and with pictures showing the terrible working conditions in the mines a hundred and more years ago. Mr. Metcalf then developed his lecture to show how the discoveries of Faraday have benefited the mining industry and how electrical energy is used to help the miner in every possible way. For instance, the proportion of methane in the air in a mine must be kept below the danger limit by adequate ventilation; and the ventilation analogue (Fig. 2) which was demonstrated enables the pressure and volume of the air in a complicated network of underground roadways to be measured. Fig. 3 shows an apparatus which dramatically emphasizes the necessity for safety precautions.

The principles of electricity are also used to make measurements of roof pressure, the amount of dust in the atmosphere, and faults in metals and ropes. All these were depicted in a series of most interesting film shots.

Improvements in underground lighting, from the early Davy lamp to the modern electric cap-lamp with polished reflector, were demonstrated.

Films and a half-scale working model of a new British power loader (Fig. 4) were used to show modern types of coal-face machinery. Methods of conveying coal to the bottom of the shaft and thence to the surface were outlined in models and films, and it was shown that although the truck belt conveyor is widely used, Diesel and battery-driven locomotives are also in service, the latter slowly overhauling the Diesel in numbers. One shot in the film showed an experimental electric pantograph locomotive which is now in use at Sandhole Colliery, Lancashire.



Methods of communication in mines, such as trolley telephones and 'wired radio', were described.

The many demonstrations in Mr. Metcalf's lecture were all obviously appreciated by the audience, but perhaps the most popular was the tower-mounted cage winder, operated from a control desk with the appropriate signals and a tape-type signal recorder.

There is no doubt that Mr. Metcalf quite lived up to the high standard which has been set by Faraday Lecturers in

2 *The ventilation of mines*

The ventilation analogue on the left has been designed to eliminate the long and laborious mathematical calculations necessary to determine the effect on a colliery's ventilation system of opening new roadways. It is demonstrated in conjunction with the model colliery layout on the right.

recent years. Apart from the prodigious amount of equipment, the smoothness of the lecture was evidence in itself of the many months of work that Mr. Metcalf and his assistants must have devoted to it before its first presentation in Cardiff last December. The lecture has also been given in Stoke-on-Trent, Nottingham, Manchester, Birmingham, Sheffield, Newcastle, Glasgow and Aberdeen—a formidable programme.

Our thanks are due to Mr. Metcalf for undertaking a marathon task and for producing a first-class lecture on a subject which is very difficult to deal with on the stage.

3 *Safety precautions*

A spectacular demonstration illustrates the necessity for the correct assembly of flame-proof equipment. The chamber contains a mixture of methane and air. When the circuit is made in the left-hand lighting fitting, only the mixture inside the glass bulb is ignited. The fitting on the right, however, has been incorrectly assembled and when its circuit is completed the flame passes to the outside atmosphere causing an explosion.

4 *A half-size model of a trepanner*

This is an example of the new coal-face machines which cut the coal and load it mechanically onto a conveyor, saving manpower and eliminating the drudgery of filling the cut coal onto the belt by hand. The machine is driven by a 70 h.p. air-cooled motor.

RADIO AND TELECOMMUNICATION SECTION

Storage tubes are comparative newcomers to the range of electronic devices, but they are rapidly finding application in many fields, and it was an interested audience which gathered on the 7th December, 1955, to listen to the presentation of the paper entitled *Some Half-Tone Charge Storage Tubes* by R. S. Webley, H. G. Lubszynski and J. A. Lodge.

The paper describes four tubes which were developed for use in radar display, and were designed to store half-tone pictures, giving long storage times with continuous reading. The information is stored in the form of a charge pattern on an insulating or semi-conducting surface, being written in, read out, and erased by means of electron beams, photo-emission or photo-conduction. Interest was added by a very effective demonstration of the operation of the tubes, with displays on television picture monitors. The full paper has already been published in the *Proceedings* [Paper No. 1883 R, July 1955 (**102** B, p. 401)] and reviewed in the *Journal* [1955, Vol. 1 (New Series), p. 596].

In opening the discussion Professor J. D. McGee said he felt he must immediately declare his interest, as they say in the House of Commons, for he had for a long time been closely in touch with the work described, and had, therefore, had a very good opportunity of seeing the trials and tribulations through which the authors had gone in producing these very elegant charge-storage tubes. He said he would, nevertheless, like to ask a number of questions, and queried why, with high-capacitance pick-up tubes, the electron multiplier was not used with the possibility of giving a much longer storage time. He further asked whether the authors had considered using evaporated layers of highly insulating materials, such as silicon monoxide, to obtain a thinner dielectric, and went on to raise other points dealing with

the design and operation of these tubes. He added that he could not agree with the statement that the sensitivity of television pick-up tubes is approaching the limit set by available photo-cathode materials, as his arithmetic indicated that there are at least two orders of magnitude in sensitivity still to be obtained before we reach the limit.

Mr. L. S. Allard said that during the past few years we had become accustomed to reading about tubes in several American papers which had unjustifiably raised our hopes, and it was praiseworthy that the present authors had not been backward in pointing out the limitations in the performance of the four tubes which they had developed. He said that perhaps the heart of slow storage tubes is the storage surface, and went on to discuss the limitations in the preparation of these targets. He also referred to the possible use of the tubes for direct viewing and in digital computers.

Mr. L. J. Braybrook discussed the application of the tubes to meet the need for bright radar displays in aerodrome control towers, where it is desirable to use radar yet see part of the airfield. He described an experimental system similar to that given in the paper, and showed graphs which indicated that at ambient illumination levels in excess of $\frac{1}{2}$lm/ft^2, at which one could just see to read and write, the television-type display tube has the advantage over the normal radar fluoride tube.

Mr. P. L. Waters said that he also had been closely associated with this project for the last few years and he spoke of his experience with the use of these tubes.

Mr. P. A. Newson asked whether the possible use of these tubes for television standards conversion had been investigated.

Mr. F. H. Townsend compared the storage time of the tubes, which varies from 10 min to 10 sec, obtained by varying the thickness of the layer, with the more normal type of photo-conductive television tube where lags of small fractions of a second are obtained, and asked whether it was possible to obtain any value desired from one extreme to the other.

Mr. A. V. Lord referred to the television applications and asked whether a storage tube could be made which would store a television picture for the period of one frame and then erase it in about a millisec.

The three authors took it in turn to give very full and detailed replies to the questions raised, after which the Chairman, Dr. R. C. G. Williams, a Vice-Chairman of the Section, proposed a vote of thanks and suggested that if we look back in about 25 years' time, many of the problems we are up against now, in transforming energy from an electron beam into light energy through a phosphor, may present a different picture. F. W.

The Progress of Pulses

A lecture of the Radio and Telecommunication Section on *Pulse Techniques, with Particular Reference to Line and Radio Communication* was delivered by Dr. E. M. Deloraine to a large audience at The Institution on the 8th February, 1956.

Once a Vice-President of the Institute of Radio Engineers of America, Dr. Deloraine traced the history of the pulse technique in communication from the eighteenth-century proposals to release bursts of energy from Leyden jars into individual wires to transmit the letters of the alphabet.

This technique, which was later to develop into a valuable aid to the transmission engineer, initially constituted a hindrance to development because the brute-force methods of d.c. pulsing were used for signalling over lines intended primarily for telephone currents of small magnitude and wide frequency bandwidth. The switching engineer was gently upbraided for using a trowel on a canvas of fine texture which called for a delicate brush, variety of colour, and breadth of vision. Signalling with trains of sinusoidal voice frequencies was not contemplated for a long time, and the inevitable result has been the existence to-day of forty incompatible types of signalling system in operation in different territories.

Present trends in electronic switching with gas tubes and transistors are tending to restore the balance, and the switching engineer now finds himself on common ground with the transmission engineer in an endeavour to eliminate infra-acoustic pulses, and to make use of audio tones for signalling. But the pulse comes into its own once more as a high-frequency burst of short duration which carries the intelligence. Baudot mutiplex thus reappears as the pulse amplitude-modulation system.

For the future, the waveguide may require pulse code modulation to overcome distortion of its own making, so that we may well find ourselves driven to a triple combination of a frequency-division system with a time-division system and again a frequency-division system, to produce the line signals. Thus all forms of communication have their value, and each problem must be considered in relation to the conditions to be met and the characteristics of the transmission path, a conclusion which blended admirably with the short film at the end, dealing with the survey, construction and commissioning of a pulse-modulation microwave system of radio links operating between the mainland of Greece and the islands in the Aegean (see photograph on page 232).

Thus, with consummate artistry, Dr. Deloraine swept across the broad canvas of communications, revealing its subtleties, its inconsistencies and its lighter touches. In his skilful hands it appeared easy to portray the past, the present and the future, with such simplicity and insight—easy perhaps because the picture he revealed he had also helped to create.

Question time at the end of the lecture was conducted in a delightfully informal way, and gave Dr. Deloraine a further opportunity for indulging his breezy practical approach to the problems of the engineer, in his replies to Capt. P. P. Eckersley, Brig. J. D. Haigh, Dr. A. R. A. Rendall, Dr. J. S. McPetrie, Mr. J. A. Smale, Mr. C. E. Strong and many others. For instance, Dr. Deloraine

had still to find a Diesel engine which would compare in reliability with a reasonably well-designed piece of radio equipment. On a question of the inherent inconsistency in the use of the term 'pulse modulation' to describe the transmitted signal, Dr. Deloraine's spontaneous remark summed up the position—'We use short cuts and what we gain in time we lose in accuracy'. On the question of the possibility of adding refinements to the Athens microwave links, the point was made that practice and the aims of science were often in conflict and the important thing was to provide communication; bursts of high-frequency oscillation were generated in a valve and transmitted in a way not so very different from the old spark transmitter method, where it was never really clear what type of modulation was being used. Refinements came along later, but these usually proved expensive.

In closing the meeting the Chairman, Mr. Stanesby, thanked Dr. Deloraine for his lucid and delightful presentation, and remarked that the broad expanse of the subject was particularly appropriate in the first year in which the Radio Section had become responsible for telecommunication. T. B. D. T.

SUPPLY SECTION

Surges of Criticism

At the meeting of the Supply Section held on the 22nd February, two papers by Dr. B. C. Robinson were discussed—*The Penetration of Surge Voltages through a Transformer coupled to an Alternator* and *The Propagation of Surge Voltages through Turbo-Alternators with Concentric-Conductor-Type Windings*; a short review of them is given on page 241. To achieve the distinction of being read, a paper must be of adequate standard, but for the discussion to be lively and interesting it should not be too perfect. According to most of those taking part, these papers avoided the second quality by a wide margin.

Opening the discussion, Mr. R. Davis confined his remarks to the first paper, in which he found little to admire and much to criticize in both content and presentation. In fact, to one mathematical artifice he applied a term commonly reserved for financial transactions of a dubious nature. He concluded with an anecdote which implied that the author was looking in the wrong place for what he could not hope to find.

Mr. E. Friedlander discussed the second paper and suggested that little advance over his own earlier work was evidenced by the new treatment.

Mr. L. W. James was concerned mainly with the problem of surge transference. He cited one case in which this phenomenon had certainly caused a failure and others where it might have done so. He referred to the American belief that it could be a serious source of trouble with shell-type transformers, but was wisely non-committal as to conditions in Britain. Mr. R. W. Flux, having expressed his gratitude to Mr. Davis for showing that authors have no special immunity south of the border, proceeded to criticize the theoretical treatment of the paper, but expressed his appreciation of the experimental work.

Mr. E. L. White also censured the theoretical treatment and proposed an alternative method, which, he showed, gives a reasonable comparison with the experimental results. Mr. J. A. S. Hilditch was critical of the equivalent circuit used by the author. He suggested that inductance was more important than capacitance at the frequencies involved. Mr. R. Bruce was concerned primarily with the effects of surges superimposed on the normal-frequency voltage, and Mr. D. H. Ryder with the problems of neutral earthing.

Apart from the general attack on the theoretical treatment, most attention was devoted to surge transference and neutral-point earthing. Mr. H. M. Lacey cited one example of serious trouble from surge transference but thought that such cases were rare. Professor M. G. Say doubted the feasibility of magnetic transference of surges and regarded any apparent dependence on turns ratio as purely coincidental. Mr. L. Csuros referred to methods of protection and must have surprised the author by expressing appreciation of the general treatment given in the paper. Finally, Mr. P. G. Ross referred to an earlier criticism of the method employed and asked for further comment.

Having been accused of most of the crimes which an author can commit, from mathematical chicanery to plagiarism, Dr. Robinson, in his reply, showed a commendable lack of contrition. His defence was that what he had set out to do had been necessary and that his methods, while not above reproach, had been the best available to him. He dealt in detail with most of the destructive criticisms and undertook to give due consideration to those of a more constructive nature.

Having regard to the highly specialized nature of the papers the meeting was well attended. Among those present was Mr. Bianchi di Castelbianco, who was due to give a lecture to the Section later in the week. He must have reached the conclusion that whatever the standard achieved by the authors of papers read before The Institution, the standard expected by its audiences left nothing to be desired. H. M. L.

UTILIZATION SECTION

Better X-Ray Pictures

On the 15th December, 1955, Dr. A. Nemet and Mr. W. F. Cox presented their paper on *Intensification of the X-Ray Image in Industrial Radiology*, a short review of which appears on page 243. In introducing their subject the authors pointed out that although there had been a steady increase in detail perceptibility, in screen brightness and in radiographic speed since the discovery of X-rays, there is still need for further improvement in all types of X-ray examination. In medical diagnosis the reduction of the X-ray dose received by patients is very desirable, and although this problem does not arise in industrial radiology the economy of examination is

nevertheless important. The introduction of the image intensifier and its development in the industrial field have enabled new applications to be achieved in fluoroscopy and miniature radiography and have also permitted more economical testing.

The ensuing discussion was opened by Dr. H. G. Taylor, who agreed with the authors that there was more scope for the device for fluoroscopy than for photography. He emphasized that this now made available to the engineer a new and valuable tool, which was of particular importance in dealing with the problem of high-speed inspection, which often occurred in industry, and in connection with articles which had to be very accurately made. Among the contributors to the discussion was the Chairman of the Measurement and Control Section, Mr. W. Bamford, who with other members of that Section was welcomed by the Chairman.

One speaker said that in the medical use of X-rays there are many details which can be discerned not merely because of their clarity but because of their movement and suggested that the possibilities of ciné-radiography in industrial work should be considered.

Reference was also made to the possibility of using an image intensifier for fluoroscopy with radioactive sources, such as isotopes.

In replying to the discussion, the authors commented briefly on experiments which had been made with television, which was used by placing an objective system between the image intensifier and the camera. This method had been applied to industrial fluoroscopy, but unfortunately the results achieved were not very good. However, it was a little too early at present to pronounce judgment on this interesting development.

Hot Statistics

There was a well-attended meeting on the 19th January to hear Mr. L. Gosland read a paper entitled *Age and the Incidence of Fires in Electrical Installations*, which was based on a report of the British Electrical and Allied Industries Research Association, and which reviewed data on the occurrence of fires due to defects in fixed electrical installations amongst a population of about 2½ million consumers over the years 1951 to 1953. From this survey, a review of which is given on page 245, although there is no clear indication of any maximum safe life, the conclusion is drawn that for installations more than 15 years old the incidence of fires is roughly proportional to the age of the installation.

In opening the discussion, Mr. S. J. Emerson could not agree that deterioration started after 15 years, as his experience showed that this was more likely to be evident after 25 years. He also instanced the fact that over 70% of some thousand fires which had been investigated in the past 8 years had been due to flexible cables and not the permanent installation.

He was followed by a large number of other speakers, representing many diverse interests, and it was somewhat intriguing to note the different interpretations which can be placed on statistical information.

One speaker pointed out that as modern cables were composed of better insulation their deterioration was less, and another contributor was of the opinion that, while fires due to cables and wires depended mainly on the age of the installation, those due to apparatus were proportional to the amount of energy transmitted, and suggested that this was of the order of one fire for every 10 million kWh.

An important point made was that age was not the only factor to be taken into consideration, because an old but well-maintained installation might be safer than a badly maintained new one.

Attention was also drawn to the importance of the earth-continuity conductor, which, in the opinion of one contributor, should be treated as a conductor in its own right and 'not as a haphazard collection of bits of iron, steel or lead'.

Altogether it was a very lively discussion, and, although the consensus of opinion appeared to be that the data available to the author were neither sufficient in scope nor spread over a period long enough to establish definitely many of the conclusions drawn, there is no doubt that the paper served a most useful purpose, both in calling attention to a very important aspect of installation work, and in stimulating an interchange of experience of this topic.

Motor Research

At the meeting on the 16th February three papers were read and discussed. The first was entitled *The Theory and Characteristics of the 3 : 1 Pole-Changing Induction Motor* and was presented by Dr. T. H. Barton, Mr. O. I. Butler and Mr. H. Sterling, who showed that by the reconnection of the primary winding of a 3-phase induction motor a machine with a 3 : 1 speed ratio can be obtained, the overall performance of which is comparable with that of two separate machines having corresponding pole numbers and the same frame size as single-speed designs. *Applications of the 3 : 1 Pole-Changing Motor* was the title of the second paper, which was presented by the same authors. This considered the application of this motor to obtain controlled starting, stopping and reversing of industrial drives.

Professor G. H. Rawcliffe and Mr. B. V. Jayawant were the authors of the remaining paper entitled *The Development of a New 3 : 1 Pole-Changing Motor*, which described a machine that gives nearly the full frame rating for both speeds and compares favourably both in torque and continuous power with normal types. Short reviews of these three papers appear on pages 245, 246 and 248 respectively.

Dr. W. J. Gibbs, who opened the discussion, was of the opinion that the importance of the papers rested mainly on the fact that they contributed to knowledge and understanding, and he also thought that although the single-winding machine might be cheaper than the two-winding machine this advantage could be lost if the switching arrangements were complicated.

One speaker observed that this country had been

accused of being fruitful in ideas but lacking in bringing them to their proper technical conclusions, but the papers were evidence that on this occasion there had been close collaboration between the universities and the manufacturing firms concerned.

The view was also expressed that it was most welcome to note the revived interest of the universities in rotating machinery and 'the despised induction motor'.

Another important point made in the discussion was that as the torque/speed curve of the particular motor described in the first two papers could be calculated not merely over the normal speed range but also when the machine was driving backwards, it was now possible for the application of a.c. dynamic braking to be developed in industry, where hitherto little interest in this matter had been shown. R. H. R.

EDINBURGH

SCOTTISH CENTRE

The Annual Edinburgh Dinner of the Scottish Centre took place under the chairmanship of Dr. E. Wilkinson on the 2nd March, 1956, when a record number of about 170 members and guests assembled. After the saying of grace, in Gaelic, the company sat down to enjoy the gastronomic and oratorical pleasures that have come to be associated with this function. The toast of 'The Institution' was proposed by Mr. Roy Thomson, who controls a number of newspapers and television circuits in Canada and is Chairman of The Scotsman Publications. After mentioning some of his early Canadian experiences Mr. Thomson referred to the need for engineers to keep in the forefront of scientific progress and to the great and successful developments that are taking place in Scotland. In reply Sir Hamish MacLaren, Vice-President, outlined some of the work on education that is being done by The Institution; he also included some nautical, but nevertheless quite proper, stories. Mr. W. B. Laing, Chairman of the South-East Scotland Sub-Centre, proposed the toast of the guests in a light and extremely diverting speech; Lord Cameron, Q.C., Senator of the Court of Session, replied in a similar vein and included some amusing tilts at the Civil Service and the Royal Navy. The evening concluded with a well-deserved and poetic tribute to the Chairman by Mr. J. E. Whittaker, Past-Chairman of the North Scotland Sub-Centre.

E. O. T.

LEEDS AND HULL

NORTH MIDLAND CENTRE

'Myself when Young . . .'

At our fifth Ordinary Meeting held on the 7th February, 1956, the Chairman Mr. F. Barrell, announced that the Annual Golf Competition in aid of the Benevolent and Homes Funds will be held on the 8th May at Sandmoor, and appealed for stronger support amongst our members for this event. He then welcomed one new Corporate Member, and the meeting proceeded to a showing of the film *The Inquiring Mind*. The audience found this a fine exposition of the case for electrical engineering as a career.

Next we were introduced to Dr. K. J. R. Wilkinson, who presented his lecture *Measurement as a Factor in Understanding*. This the author described as ranging from 'the simplicity of mass' to the 'complexity of colour'; he said that measurement fell into two groups, magnitude and quality, and drew our attention to the three different pictures of a problem which present themselves to a mathematician, a physicist, and an electrical engineer. He dealt with the relationship between faith and understanding, with extra-sensory perception and finally with epistemological scepticism. He had some interesting things to say about the superposition theory, and described researches with the cyclotron and betatron. The discussion, which was opened by Professor G. W. Carter and supported by four other members, must have shown the author our interest in his discourse, and may also have given him a measurement of our understanding. Our Chairman, in proposing a hearty vote of thanks, expressed our appreciation for a most thought-provoking evening. J. L.

NORTH MIDLAND UTILIZATION GROUP

At the well-supported third Group Meeting, held on the 17th January, 1956, our Chairman, Mr. J. C. W. Wilkinson, introduced Mr. W. Holttum and called upon him to present his paper entitled *The Installation of Metal-Sheathed Cables on Spaced Supports*. This rather specialized subject was admirably dealt with by the author, who indicated the limitations of cables on supports set closely together. A demonstration with a model illustrated the point, and the author went on to prove that wider spacing of supports prevented lateral movement of the cable, which is the primary cause of concentrated sagging and of subsequent failures. The paper was well illustrated with lantern slides, and was received enthusiastically by the audience. The discussion, which was opened by Col. H. B. Somerville and taken up by many other speakers, showed interest in most aspects of the topic. Power distribution, railway signalling and telephone cables were discussed at some length, and the interest was unflagging when time forced the Chairman to close the meeting with a vote of thanks to the author. J. L.

DISTRICT MEETING

Chairman's Address

The third District Meeting was held on the 19th January, 1956, when we were delighted to welcome the Centre Chairman, Mr. F. Barrell. At a pleasing ceremony Mr. W. S. Milner, our convener, presented to Mr. Barrell two new Corporate Members. Mr. Barrell then

delivered his Chairman's Address entitled *The Development of Power-Station Construction in Leeds and the Surrounding Area*. This was illustrated by many excellent coloured slides of new power stations in the various stages of construction. After a short interval following the Address, the Chairman was good enough to answer a number of questions put by four local members on the subject-matter of the Address, and at the conclusion of this discussion a vote of thanks to Mr. Barrell was proposed by Mr. S. Gower. J. L.

LOUGHBOROUGH

EAST MIDLAND CENTRE

The Graduates and Students Section organized a Brains Trust at Loughborough on the evening of Tuesday, the 31st January, when thirty-six members attended. The members of the Brains Trust were Mr. F. Jervis Smith, Deputy Secretary of The Institution, Mr. R. G. Hooker, Dr. H. L. Haslegrave, Mr. W. Parkin and Mr. T. Pollard.

The questions were on many topics, such as the Government plans for the development of technical education; the entry of non-science graduates into industry; the development of automatic control on railways; the doubt of commercial engineering experience being acceptable for admission to Associate Membership; the failure to appoint engineers to the highest administrative posts in industry and the Civil Service and the value of technical qualifications. For almost each question there was a very ready response from the floor of the meeting to take part in the discussion after the Brains Trust had given its opinions.

Refreshments were served during an interval in the proceedings, during which there were many informal conversations between members of the Brains Trust and the Graduates and Students. These discussions were continued after the meeting. The members of the Section welcomed very much the opportunity of meeting the Deputy Secretary personally, and, in addition, of being able to discuss with him some of their own private difficulties. W. A.

RUGBY

RUGBY SUB-CENTRE

Local Colour

The 1955–56 Session has probably been one of the most successful at the Rugby Sub-Centre since it was started in 1945. So far seven meetings have been held and the average attendance has been about 100.

On four occasions the 'house full' notices have been necessary. The first of these was the joint meeting with the Rugby Engineering Society when a lecture on *Colour Television* was presented by Mr. B. V. Somes-Charlton. An equally popular lecture was that entitled *Atomic Power Stations* by Mr. D. F. Welch, in which he described the progress which had been made to date, and gave some peeps into future possibilities of atomic power. There was an enthusiastic audience for the paper by four local members, Mr. T. H. Kinman, Mr. G. A. Carrick, Mr. R. G. Hibberd and Mr. A. J. Blundell, entitled *Germanium and Silicon Power Rectifiers*, which was an account of development work carried out at Rugby.

Perhaps the most outstanding success of the session was the paper by Capt. C. F. Booth and Mr. B. N. MacLarty on *The New High-Frequency Transmitting Station at Rugby*. On this occasion, through the courtesy of the Post Office, the meeting was held at the new radio station which was the subject of the paper. After the meeting, parties of members were conducted round the establishment on a very interesting tour. Our thanks are due to Mr. G. H. Fogg, the Engineer-in-Charge, for the arrangements which he made. The elegance and the engineering design of the new station made a vivid impression on everyone present.

The informal speakers' supper parties have continued to be held at the Grand Hotel after the meetings. These have proved to be excellent social occasions, with the conversation ranging over a wide field of subjects in addition to electrical engineering. One supper party was brought to an end only by one member knocking out his pipe on an ashtray; the gathering thought this was a call to order by the Chairman to draw attention to the lateness of the hour.

It was our privilege to organize a District Meeting at Banbury when Mr. H. R. Ruff and Mr. R. V. Mills gave a talk on *Progress in Lamps and Lighting*. This lecture was illustrated by many colourful experiments. E. S. H.

OXFORD

DISTRICT MEETING

'Safety from Fire and Shock'

A general discussion on *Modern Developments in the Wiring of Buildings* took place at the Southern Electricity Board's district office on the 8th February. The meeting was attended by fifty-one members and their guests, including some local architects to whom invitations had been extended.

The discussion was opened by a panel of three speakers who spoke for a few minutes each. Mr. J. J. Looker reviewed developments in The Institution's Wiring Regulations over the last few years, and also referred to associated regulations and British Standard specifications. Mr. A. Andrews spoke about practical developments, referring specially to the various trunking systems, wiring systems and the application of the 13amp universal-socket outlet with the ring-main system. He used some interesting slides to illustrate his comments. The third opening speaker, Mr. R. Bury, dealt with materials, and with the aid of various pieces of demonstration equipment and components, described the modern trends in design with particular reference to

combined service, consumers' units and ring-main accessories.

A full and lively discussion developed ranging from earthing problems to utilization, until it was necessary for the Chairman to terminate the discussion due to the lateness of the hour. It seemed that a very useful purpose had been served by the meeting. A vote of thanks to the Chairman and panel was proposed by Mr. D. E. Westwood. A. A.

READING

DISTRICT MEETING

Mr. J. L. Bates presided at the meeting held on the 16th January for the talk on *Developments in Lighting Techniques* by Mr. L. H. Hubble. The attendance was thirty-two.

Mr. Hubble reviewed lamp and equipment development, which has now been brought to a stage where, with the availability of ample electrical energy, it is possible to plan for the artistic utilization of light to a degree never before achieved. The development of lighting equipment generally, and of the fluorescent lamp in particular, with relation to the flexibility of lighting installations and their integration with building structures, was outlined. The talk was illustrated with a number of slides and was followed by an interesting discussion.

Mr. Forbes Jackson expressed the thanks of the members to Mr. Hubble for his interesting and informative talk. P. J. B.

NEWS *from Abroad*

OVERSEA ATTENDANCE REGISTER

During the period 1st February to 29th February, 1956, the following members called at the Institution Building and signed the Attendance Register of Oversea Members:

COATESWORTH, Major D., M.B.E., M.SC.TECH. (Munchen Gladbach, Germany).
COPELAND, J. (Singapore).
JOHNSON, D. A. H., M.SC. (Wellington, New Zealand).
PATEL, S. P., B.SC.(ENG.) (Nadiad, India).
PUROHIT, V. T. (Bombay).
STEPHAN, E. (Ramallah, Jordan).
WILSON, G. L., M.A., B.SC. (Hamilton, Ontario).

BRISBANE

QUEENSLAND OVERSEA COMMITTEE

The 1955 Christmas Luncheon

The Bellevue Hotel, Brisbane, was again selected for the Christmas Luncheon arranged for members visiting or resident in Queensland. This function, which was held this time on the 8th December, retained its popularity with members, approximately forty of whom welcomed the opportunity of exchanging the season's greetings with their fellow engineers. As has been the custom, The Institution limited invitations to one guest—on this occasion the Commissioner for Electricity Supply, Mr. H. N. Smith. The toasts honoured were 'Her Most Gracious Majesty Queen Elizabeth II' and 'Our Guest'.

On introducing The Institution's guest to members, the Chairman, Mr. J. S. Just, took the opportunity of extending Christmas greetings to all present, and in response to the toast proposed to him Mr. Smith delivered a very interesting speech on the development of the electricity supply industry in Queensland, giving members an outline of what progress has been achieved in the past eighteen years, and an indication of expected development during the coming decade. A vote of thanks to Mr. Smith was moved by Professor S. A. Prentice.

On behalf of all members, Mr. A. E. Axon thanked the Chairman and members of the Queensland Oversea Committee for their work during the year, and suitable response was made by the Honorary Secretary, Mr. A. S. Faulkner. A. S. F.

IRELAND

IRISH OVERSEA BRANCH

Alive to the Future

The activities of the Irish Branch during the current session have not shown any signs of abating compared with the good records of previous sessions. Attendances at Committee and Ordinary General Meetings have been, as usual, very satisfactory.

Amongst the Committee's more outstanding items of work was the preparation of a report for submission to the recently formed sub-committee on Technological Education set up by the Dublin Vocational Education Committee. The report, which was drafted after consultation with The Institution in London, dealt mainly with the education and training of professional electrical engineers and electrical technicians. It was highly valued by the Education Committee, important officials of which visited the Education Officer of The Institution in London, thus establishing a useful liaison on matters of mutual interest in the education and training of prospective electrical engineers. After the submission of this report, The Institution film *The Inquiring Mind* was exhibited to several schools and colleges in the Dublin area with, we think, good results.

Not the least important event in our programme was the delivery of the Faraday Lecture by Mr. T. B. D. Terroni on *Courier to Carrier in Communications*, at the Mansion House, Dublin, before a large and appreciative audience, many of whom subsequently said how much they had enjoyed the lecture and the demon-

strations. We were privileged on this occasion to have the presence of the Minister for Education, General Mulcahy, who presided and introduced the lecturer to the audience.

The Graduates and Students Section, established during the last session on a trial basis, has kept up its initial enthusiasm and promises to justify its formal recognition by headquarters after the trial period of two years. A beneficial feature of the meetings is the number of regular visitors from amongst university students, who thus help indirectly to encourage their fellow students to become professional electrical engineers.

The Irish Branch Annual Dance has become very popular during the past two or three years, and is now well established as one of the outstanding social functions of its kind in Dublin. At this session's Annual Dance, held in February, we were favoured by the presence of the President, Sir George Nelson, and Lady Nelson, together with the Secretary and Mrs. Brasher. As is now customary, we also had as our guests some of our colleagues from the Northern Ireland Centre—the Chairman, Major E. N. Cunliffe, the Senior Vice-Chairman, Mr. D. S. Parry, and the Hon. Secretary, Mr. T. S. Wylie, with their wives.

Of developments in electrical engineering in the country since last year mention may be made of the commissioning of the first two sets at the Ringsend generating station in Dublin, using dual-fuel-fired (coal and oil) boilers, with an initial capacity of 90 MW and provision for extension up to 210 MW. The milled-peat-fuel generating station still under construction near a large bog in the vicinity of Ferbane, Co. Offaly, is nearing the completion of its first stage of development, and tests are likely to be made about the middle, or towards the end, of the present year. The Post Office recently brought into service for the first time in this country a Telex system on a limited scale, but this system is expected to expand as its advantages become better known among industrialists and other potential users.

As in most other countries, large and small, great interest is taken here in the future use of nuclear energy for generating stations, and Irish engineers in general were most interested in the offer from the United States Government (1) to lease supplies of enriched uranium to friendly countries to enable such countries to set up nuclear reactors for research and training purposes, (2) to bear half the cost of the reactors and (3) to render technical assistance in establishing them. An aspect of the offer which is of considerable moment to small countries such as ours is the fact that a small type of research reactor using enriched uranium can be constructed at low cost compared with that of the large type using natural uranium and costing several million pounds. At a special meeting of the Engineers Association, representing all branches of the engineering profession, a resolution that the Irish Government should take advantage of this offer was passed by a large majority, and a suitable memorandum was submitted subsequently to the responsible Ministers of the Government. The offer has now been accepted by the Government. J. D. F.

KUWAIT

IRAQ AND PERSIAN GULF JOINT OVERSEA GROUP

Members of the Iraq and Persian Gulf Joint Oversea Group held their December, 1955, meeting in the State of Kuwait.

The contingent of members from the Zubair oil fields near Basra which past meetings in Kuwait have led us to expect was deterred by the threat of rain which falls about this time in most years. Whether the weather was more menacing to the installations they tend or the lengthy desert tracks they so indomitably motor over we were left to guess. However, two of them and our lady Secretary from Baghdad appeared off the daily Iraq plane when it arrived on Thursday, 15th December. Although they were well represented at meetings earlier in the year, most members in Abadan also failed to put in an appearance. But those who did come to Kuwait were joined in the afternoon by a strong gathering of members resident in the district to hear a paper on *The Sand Lime Brick—Plant and Product*, written and presented by Mr. George Walker, and vigorously discussed by members of all grades and Institutions.

The paper and the discussion were mainly historical and factual, relating the discovery of suitable indigenous raw materials and the development of processes and plant to handle them. Suitable sand is found about three miles from the town of Kuwait; limestone occurs in deposits about twenty miles away; and fuel is available in the form of natural gas occluded from crude oil when the natural reservoir pressure is released at the processing centres in the Magwa and Burgan oil fields, 12–30 miles to the south.

On the Friday morning (the weekly day off in many Moslem states) some two-dozen members inspected the brick plant now in an advanced stage of construction near the sand deposits. The lime processing plant is not yet complete but batching plant and brick presses are producing experimental batches of bricks to determine the most favourable proportions of mix and operating conditions.

To conclude the meeting, those members who were free to do so proceeded to the I.T.A. Hotel, where a very good lunch was enjoyed by all.

The Group are indebted to the Kuwait Oil Company, which repeatedly offers facilities at its headquarters at Ahmadi (twenty miles from Kuwait town) for meetings to be held, and for the hospitality and social activities which frequently accompany the meetings there.

Particulars of the Group's future activities may be obtained from the Secretary, whose address will be found on page 200 of the March issue. J. A. C. K.

RIO DE JANEIRO

A New Joint Group?

A meeting of twenty-two members in Brazil took place on the 3rd February, 1956, at the Club Ginastico Portugues, Rio de Janeiro. The programme comprised a dinner and a formal discussion about the possibility of recommending to the Council the formation of a local organization in Brazil.

The dinner took place in pleasant surroundings and everyone present was glad of the opportunity of getting to know other members in Rio de Janeiro. They much appreciated a message from the President that was read out at the end of the dinner, and a cable was dispatched thanking him for it.

As a result of the discussion it was decided to investigate the practicability of setting up a Joint Oversea Group in Brazil. Until members in Brazil are formally organized they will keep in touch with each other through occasional *ad hoc* meetings such as the dinner and discussion on the 3rd February.

SYDNEY

At a joint meeting of The Institution of Electrical Engineers and The Institution of Engineers, Australia, held at Science House, Sydney, on the 26th October, 1955, Mr. C. H. Flurscheim read a paper entitled *Air-Blast Circuit-Breakers for High-Voltage Networks*. About 120 members from both Institutions attended the meeting and participated in the lively discussion which always occurs when the relative merits of small-oil, bulk-oil and air-blast circuit-breakers are under review.

Mr. Flurscheim pointed out that the recent rapid expansion of very-high-voltage transmission systems throughout the world, and in particular the raising of the maximum transmission voltage to 400 kV, have made it necessary for designers to review the basic principles of h.v. switchgear design so as to ensure that the most appropriate techniques are employed. He went on to review h.v. network requirements and to lay down the basic ideals of performance which switchgear has to meet under conditions pertaining at present and in the foreseeable future.

He gave a very welcome insight into the active research which is being carried out on the development, manufacture and testing of modern British switchgear, and concluded by demonstrating how closely the air-blast principle, when correctly applied, approaches the ideals of switching performance which he had previously laid down.

Mr. Flurscheim's paper was particularly appropriate, as plans for the building of a 330 kV transmission system in New South Wales are well advanced. J. T. R.

TRINIDAD

The Annual Dinner held jointly by the three senior engineering Institutions in Trinidad took place on the 21st January, 1956, and was a most successful function. Twenty-five members of The Institution were present with their ladies.

The official guests included His Excellency the Governor and Lady Beetham, the Acting Colonial Secretary and Mrs. Solomon Hochoy, the Minister of Communications and Works, the Chairman of the Trinidad Branch of The Institute of Petroleum and the Chairman of the Trinidad and Tobago Electricity Commission.

Mr. D. D. Ash, Chairman of the Trinidad Branch of the British West Indies Association of The Institution of Civil Engineers, was in the chair, and in a speech which received much publicity in local newspapers said, 'We have seen all too clearly in recent decades how works of engineering built for humanity have been used for human destruction. We have seen public funds wasted, due to improper engineering supervision, and we have seen conditions detrimental to the health and welfare of this community allowed to arise and continue without raising our voices. These things are happening because of our preoccupation with the slide rule and the sooner we begin to take a more active part in the life of the community, the better it will be for us and the community.'

The Governor proposing the toast of 'The Institutions' said engineering was one of the oldest professions. He praised members for their considerable achievements in the past and expressed the hope that they would continue in the future.

An old monastery and a new microwave link provide contrasts on the island of Santorin [see 'The Progress of Pulses', page 225]

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The Annual Dinner of The Institution

H.R.H. THE DUKE OF EDINBURGH RECEIVES THE CERTIFICATE OF HONORARY MEMBERSHIP

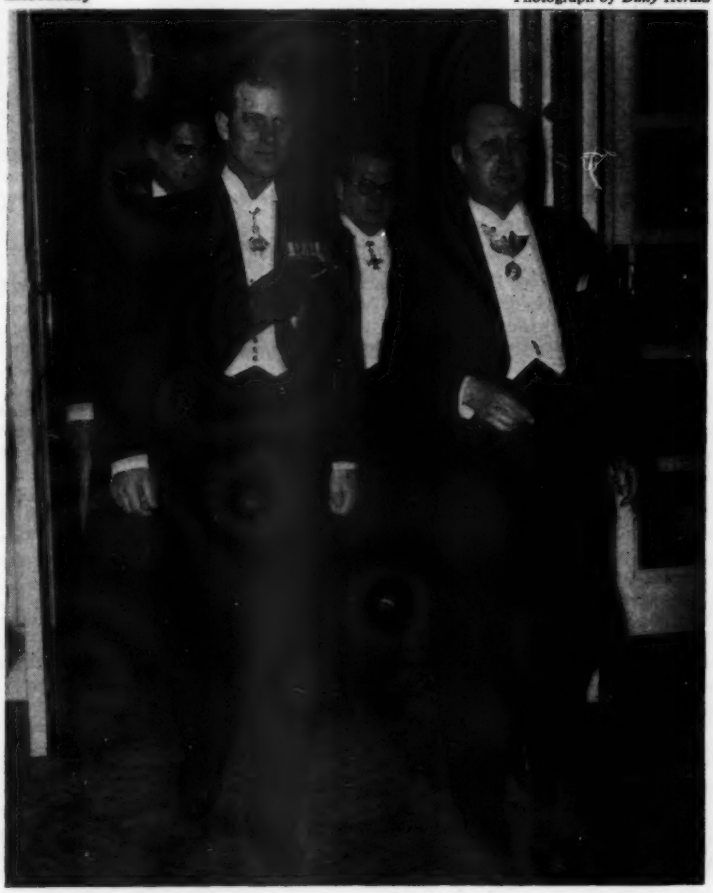
THE Annual Dinner of The Institution was held at Grosvenor House, Park Lane, on the 23rd February, 1956. The President, **Sir George Nelson, Bart.**, presided over a distinguished gathering of over 1450 members and guests, who were honoured by the presence of **H.R.H. The Duke of Edinburgh, K.G., P.C., K.T., G.B.E., F.R.S., Hon. Member.** At the conclusion of the Dinner the President presented His Royal Highness with a scroll holder containing a Certificate of Honorary Membership of The Institution.

Among those present were:

His Excellency The Hon. Sir Thomas White, K.B.E., D.F.C., V.D. (*High Commissioner for the Commonwealth of Australia*); His Excellency Marquis du Parc Locmaria, C.V.O. (*Ambassador for Belgium*); His Excellency Monsieur V. de Steensen-Leth (*Ambassador for Denmark*); His Excellency Monsieur S. Tuomioja (*Ambassador for Finland*); His Excellency Herr Hans von Herwarth (*Ambassador for the Federal Republic of Germany*); His Excellency Monsieur D. U. Stikker, G.B.E. (*Ambassador for the Netherlands*); His Excellency The Hon. Sir Clifton Webb, K.C.M.G. (*High Commissioner for New Zealand*); His Excellency Monsieur Per Prebensen, G.C.V.O., C.B.E. (*Ambassador for Norway*); Sir Gilbert Rennie, G.B.E., K.C.M.G., M.C. (*High Commissioner for the Federation of Rhodesia and Nyasaland*); His Excellency Mr. G. P. Jooste (*High Commissioner for the Union of South Africa*); His Excellency The Hon. Winthrop W. Aldrich, G.B.E. (*Ambassador for the United States of America*); The Most Hon. The Marquess of Reading, C.B.E., M.C., T.D., Q.C. (*Minister of State for Foreign Affairs*); The Rt. Hon. Patrick Buchan-Hepburn, M.P. (*Minister of Works*); The Rt. Hon. Aubrey Jones, M.P. (*Minister of Fuel and Power*); The Rt. Hon. the Viscount Falmouth (*Honorary Treasurer*); The Rt. Hon. the Viscount Waverley, G.C.B., G.C.S.I., G.C.I.E., F.R.S. (*Chairman, Port of London Authority*); The Rt. Hon. Lord Citrine, P.C., K.B.E., LL.D. (*Chairman, Central Electricity Authority*); Sir Charles Bruce-Gardner, Bart. (*President, The Iron and Steel Institute*); Sir Noel Ashbridge, B.SC.(ENG.) (*Past-President*); Sir Harold Bishop, C.B.E., B.SC.(ENG.) (*Past-President*); Sir John Cockcroft, K.C.B., C.B.E., M.A., PH.D., D.SC., F.INST.P., F.R.S. (*President, The Institute of Physics*); Admiral Sir Ralph Edwards, K.C.B., C.B.E. (*Third Sea Lord and Controller*); Sir Arthur P. M. Fleming, C.B.E., D.ENG., LL.D. (*Past-President; Honorary Member*); Sir Gilbert Flemming, K.C.B. (*Permanent Secretary, Ministry of Education*); Sir Archibald J. Gill, B.SC.(ENG.) (*Past-President*); Sir Graham Hayman (*President, Federation of British Industries*); Sir Laurence Helsby, K.B.E., C.B. (*First Commissioner, Civil Service Commission*); Sir Cyril Hinshelwood, M.A., D.SC., F.R.S. (*President, The Royal Society*); Sir Godfrey H. Ince, G.C.B., K.B.E.; Lt.-General Sir Ian Jacob, K.B.E., C.B. (*Director-General, British Broadcasting Corporation*); Sir Gilmour Jenkins, K.C.B., K.B.E., M.C. (*Permanent Secretary, Ministry of Transport and Civil Aviation*); Sir David L. Keir, M.A. (*Master of Balliol College, Oxford; Chairman, Advisory Committee on Colonial Colleges in Arts, Science and Technology*); Sir Frank Lee, K.C.B., C.M.G. (*Permanent Secretary, Board of Trade*); Sir Hugh Linstead, O.B.E., M.P. (*Chairman, Parliamentary and Scientific Committee*); Sir Ben Lockspeiser, K.C.B., F.R.S. (*Secretary, Department of Scientific and*

The Duke of Edinburgh entering the ball-room of Grosvenor House with the President before dinner

Photograph by *Daily Herald*



Photograph by Keystone Press

Mr. Eccles receives Sir Godfrey Ince

Photograph by Keystone Press

. . . and the American Ambassador

Industrial Research); Sir Hamish D. MacLaren, K.B.E., C.B., D.F.C., LL.D., B.SC. (*Vice-President*); Sir Keith Murray, B.SC., PH.D., M.A., B.LITT. (*Chairman, University Grants Committee*); Sir Gordon Radley, C.B.E., PH.D.(ENG.) (*Vice-President; Director-General, Post Office*); Sir Harry Railing, D.ENG. (*Past-President; Honorary Member*); Sir Henry Self, K.C.B., K.C.M.G., K.B.E. (*Deputy Chairman, Central Electricity Authority*); Lt.-General Sir Ronald Weeks, K.C.B., C.B.E., D.S.O., M.C., T.D. (*Chairman, National Advisory Council on Education for Industry and Commerce*); W. G. Agnew, C.V.O. (*Clerk of the Council, Privy Council*); E. H. Ball (*Chairman, The British Electrical and Allied Manufacturers' Association*); J. R. Beard, C.B.E., M.SC. (*Past-President; Honorary Member*); E. Bolton, B.SC.TECH. (*Hon. Secretary, North Staffordshire Sub-Centre*); F. Bray, C.B. (*Under Secretary, Ministry of Education*); E. G. Brentnall, B.E.M., M.ENG. (*President, The Institute of Railway Signal Engineers*); R. Bruce, M.SC. (*Joint Hon. Secretary, North-Eastern Centre*); H. A. Carr (*Hon. Secretary, North Midland Centre*); Sqdn.-Ldr. H. M. Chinnery, A.F.C. (*Equerry to H.R.H. the Duke of Edinburgh*); R. A. W. Connor (*Hon. Secretary, East Anglian Sub-Centre*); A. Cooper (*Surveyor of Lands, Duchy of Lancaster*); A. R. Cooper, M.ENG. (*Member of Council*); E. H. Cox (*Hon. Secretary, South Midland Centre*); A. T. Crawford, B.SC. (*Member of Council; Joint Hon. Secretary, North-Eastern Centre*); Rev. C. L. Cresswell, C.V.O., M.A., F.S.A. (*Chaplain of the Queen's Chapel of the Savoy; Chaplain to the Council*); J. A. Crowe (*Chairman, Telecommunication Engineering and Manufacturing Association*); Lt.-Col. H. S. Davidson, T.D. (*Chairman, South Midland Centre*); G. B. Devey (*Hon. Secretary, South-Western Sub-Centre*); J. H. P. de Villiers (*Hon. Secretary, Scottish Centre*); G. L. Doig, B.SC.(ENG.) (*Hon. Secretary, North Scotland Sub-Centre*); J. M. Donaldson, M.C. (*Past-President; Honorary Member*); Capt. A. D. Duckworth, R.N.(RETD.) (*Secretary, The Institution of Naval Architects*); P. R. Dunn, B.SC. (*Past Chairman, Mersey and North Wales Centre*); P. Dunsheath, C.B.E., M.A., D.SC.(ENG.) (*Past-President*); J. Eccles, C.B.E., B.SC. (*Immediate Past-President*); T. T. Evans (*Hon. Secretary, North-Western Centre*); J. D. Ferguson, B.SC.(ENG.) (*Hon. Secretary, Irish Branch*); F. F. Freeling (*Hon. Secretary, Western Centre*); S. E. Goodall, M.SC.(ENG.) (*Vice-President*); C. E. T. Cridland (*President, The Scientific Instrument Manufacturers' Association*); R. H. Gummer (*President, The Institute of Fuel*); T. G. N. Haldane, M.A. (*Past-President*); E. S. Hall (*Hon. Secretary, Rugby Sub-Centre*); J. Harley [*Hon. Secretary, West Wales (Swansea) Sub-Centre*]; K. Headlam-Morley (*Secretary, The Iron and Steel Institute*); A. G. Higgins (*President, The Illuminating Engineering Society*); H. W. Housley (*Hon. Secretary, Southern Centre*); Professor G. W. O. Howe, D.SC., LL.D. (*Faraday Medallist 1956*); W. K. Hutchison, C.B.E., B.A., B.SC. (*President, The Institution of Gas Engineers*); P. V. Hunter, C.B.E. (*Past-President; Honorary Member*); Willis Jackson, D.SC., D.PHIL., DR.SC.TECH., F.R.S. (*Vice-President*); P. L. Jones, M.C. (*President, The Institution of Mechanical Engineers*); M. J. Kelly, PH.D., D.ENG., D.SC., LL.D.; Dr. D. W. Kent-Jones, B.SC. (*President, The Royal Institute of Chemistry*); Col. B. H. Leeson, C.B.E., T.D. (*Past-President*); E. Leete (*Honorary Member*); Dr. P. Linstead, C.B.E., F.R.S. (*Rector of the Imperial College of Science and Technology*); Major-General W. A. Lord, C.B., C.B.E. (*Director of Mechanical Engineering, War Office*); T. G. Lund, C.B.E. (*Secretary, The Law Society*); Dr. A. Macrea, M.A. (*Secretary, British Medical Association*); R. A. Marryat, B.SC.

(*President, The Electrical Contractors' Association*); Dr. D. C. Martin, B.SC. (*Assistant Secretary, The Royal Society*); A. McDonald, B.SC. (*Secretary, The Institution of Civil Engineers*); Professor J. M. Meek, D.ENG. (*Chairman, Mersey and North Wales Centre*); J. F. Mentasti (*Chairman, The Society of X-Ray Technology*); Professor E. B. Moullin, M.A., SC.D. (*Past-President*); J. Muil (*Registrar and Secretary, Professional Engineers Appointments Bureau*); E. F. Muir, C.B. (*Permanent Secretary, Ministry of Works*); J. A. Oriel, C.B.E. (*President, The Institution of Chemical Engineers*); Rear-Admiral K. H. T. Peard, C.B.E. (*Director, Naval Electrical Department*); J. S. Pickles, B.SC. (*Chairman, South of Scotland Electricity Board*); H. T. Price (*Hon. Asst. Secretary, East Midland Centre*); R. W. C. Reeves (*Chairman, The Cable Makers' Association*); Dr. W. Reid (*President, The Institution of Mining Engineers*); B. G. Robbins, M.SC.(ENG.) (*Secretary, The Institution of Mechanical Engineers*); C. E. Smith, B.SC.(ENG.) (*Hon. Secretary, North Lancashire Sub-Centre*); Dr. R. L. Smith-Rose, C.B.E., D.SC. (*Member of Council: Acting Director, National Physical Laboratory*); R. Somerville, C.V.O. (*Clerk of the Council, Duchy of Lancaster*); R. L. Stanley (*Hon. Secretary, South-West Scotland Sub-Centre*); G. I. Thomas, B.SC. (*Hon. Secretary, South-East Scotland Sub-Centre*); S. Towill, B.SC.(ENG.) (*Hon. Asst. Secretary, Mersey and North Wales Centre*); J. S. Tritton (*Chairman, The Association of Consulting Engineers*); J. A. Walker (*Hon. Secretary, Sheffield Sub-Centre*); W. K. Wallace, C.B.E. (*President, The Institution of Civil Engineers*); G. L. Wates, J.P. (*Member of Council*); G. O. Watson (*Member of Council*); E. L. E. Wheatcroft, M.A. (*Member of Council*); Dr. H. F. Willis, M.SC. (*Chief of the Royal Naval Scientific Service*); T. S. Wylie (*Hon. Secretary, Northern Ireland Centre*); H. T. Young (*Past-President*); and W. K. Brasher, C.B.E., M.A. (*Secretary*).

Apart from the High Table, the diners were this year all seated at small tables having about ten chairs each, which allowed the maximum number to be accommodated in the Great Room of Grosvenor House. In previous years there had been long tables on the main floor with a few small tables on the balcony. Many members found the new arrangement more friendly, if inevitably a trifle more congested, and one that benefited conversation during the Dinner.

The dinner began with Grace said by the **Rev. C. L. Cresswell**, Chaplain to The Institution.

The Loyal Toasts were proposed by the President and duly honoured. The **President** then said:

'It is the custom at our Annual Dinner for the Immediate Past-President to welcome distinguished guests in his toast to the Guests, but this is such a special occasion that I am sure that you would wish me, as President, to welcome our principal guest to-night, His Royal Highness The Duke of Edinburgh, and to say how greatly honoured we are at his presence.

'You will also wish me to ask His Royal Highness to convey to Her Majesty the Queen, our Patron, an assurance of our deep loyalty and devotion to her and our immense admiration and sincere gratitude for all that Her Majesty does for us and for her subjects throughout this great Commonwealth. She is indeed an inspiration to us all.

'Referring now to your Royal Highness's gracious acceptance of our invitation to become an Honorary Member of The Institution, which now numbers 40 000 members, this has indeed given us all immense pleasure and encouragement, emphasizing, as it does, your deep interest in the science and technology of professions like ours, whose work contributes to the improvement of the lot of mankind everywhere. This honour is the highest that we can bestow and we have so jealously guarded its prestige that there are at present only fifteen Honorary Members. Its standing will be even more enhanced by your gracious acceptance.

'May I now, Sir, present the Certificate of Honorary Membership of The Institution and beg you to be good enough to sign our Roll of Honorary Members.'

His Royal Highness was then given by the President the graceful silver-gilt scroll holder, which had been specially designed and engraved for the occasion. A photograph and description of the scroll holder appear on p. 236. Next His Royal Highness signed, in permanent ink, the new Roll of Honorary Members and Faraday Medallists which The Institution has recently had prepared. This Roll, which is a sumptuously produced book, bound in leather and lettered throughout on hand-made paper, contains the names and short citations of all the Honorary Members and Faraday Medallists since The Institution was founded, together with photographs of those who have received their awards since 1921. A photograph and description of it will be published in a future issue.

H.R.H. The Duke of Edinburgh then rose to propose the toast of 'The Institution of Electrical Engineers'. He said:

'First of all I should like to thank you very much indeed for making me an Honorary Member of The Institution of Electrical Engineers, and for this scroll. I assure you that I fully appreciate what a very great honour it is for a layman. I ought to confess that my knowledge of electricity is limited to a rather vague recollection of Ohm's law and the sort of confused things that one picks up when visiting electrical industrial concerns such as your President's. In fact, I probably know more about learned and professional institutions than I do about electrical engineering.

'Incidentally, I hear that there has been a sympathetic reaction on the sun to this remarkable gathering of electrical engineers. I do not know whether you listened to the B.B.C.'s evening news broadcast, but, according to it, the Royal Greenwich Observatory announced that early to-day a remarkable event occurred on the sun which resulted in a large increase in cosmic-ray intensity for about two hours.

'Being so ignorant of your particular profession perhaps allows me to plunge where more knowledgeable Members or Honorary Members might fear to tread. It is my invariable custom to say something flattering to begin with so that I hope you will excuse me if I put my foot in it later on.

'Everything that I have read or heard about this Institution makes it very clear that it is doing a most useful and important job of work, because one of the most difficult problems facing any professional man to-day must be how to keep abreast with all the new

ideas, new methods and new processes which are contained in such a mountain of technical literature. Acting as a clearing house, The Institution can obviously be of immense help to its members all over the world.

'I see also that The Institution tries to ensure that the professional standards of its members are maintained at a high level. I am delighted to see it, but far be it from me to comment on that aspect of your work except to say this: I have travelled about the Commonwealth in recent years—as you may occasionally have noticed—and I know that the scope for engineers of all sorts in all parts of the world is almost unlimited. But the competition is extremely keen, and unless we can keep up with the best and the latest of other countries, our services will no longer be required. On the other hand, if we can keep ahead of our rivals, the prospect is really bright.

'I gather also that The Institution is trying to increase the number of recruits to electrical engineering. I am not at this particular moment speaking as the latest recruit, because statistically I count only as one "Hon. Member" anyway; but it is well known and well recognized that this country is short of engineering students of all kinds, and unless you can do something about it, we shall be feeling the pinch with increasing pain in the years ahead. Mere knowledge of this problem is not of course a solution. Therefore, I wish you every success in this particular branch of your work, which is in fact a practical contribution to the solution of this very difficult problem.

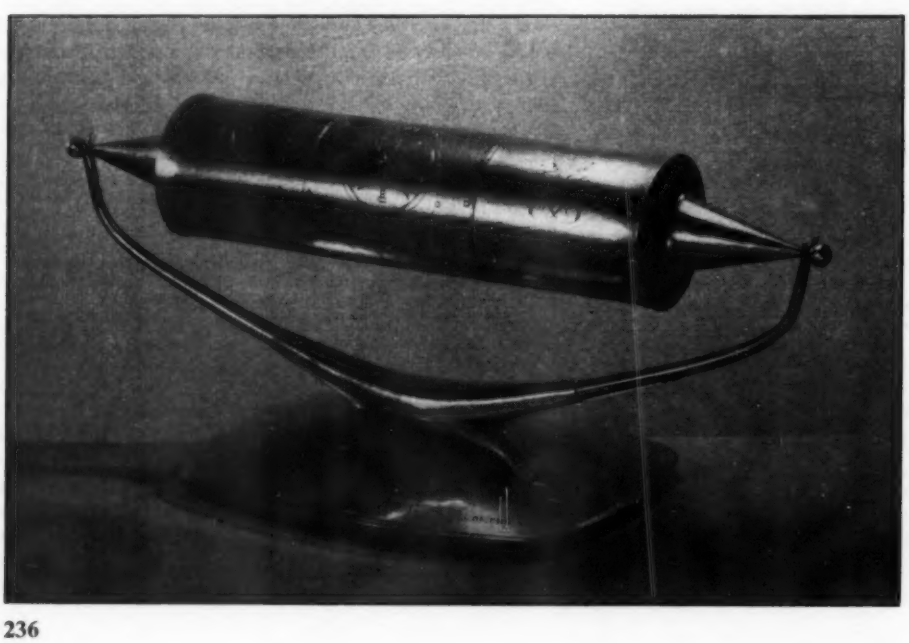
'I imagine that one of the outstanding contributions of electrical engineering to the country's economy has been the very considerable increase in the efficiency with which our fuel resources are being converted into power. Power in any quantity from nuclear sources is still a long way off, and in the meantime we must make the best use of our dwindling coal and our imported oil. Waste in the days when fuel was cheap and plentiful is perhaps understandable, but to-day it is inexcusable.

'Your industry is also helping our economy by its very large share of our export trade and by making it possible for all other industries to increase their productivity, and I need hardly add that in our present situation this is more important than ever.

'I am also glad to see that The Institution encourages research. Looked at in the future research demands faith and money. In the present it demands patience and money, and it is only in retrospect that research is seen in its true importance; I think that Sir Gordon Radley and Dr. Kelly, the architects of the transatlantic cable, whom I am delighted to see here this evening, may bear me out in that.

'I think that many people look upon research as something that might help the conjurer to produce an elephant out of his hat instead of a rabbit. It does sometimes, but most of the time it is helping the conjurer to produce a bigger and better rabbit out of a smaller and cheaper hat. If that remark means as little as I think it does, let me put it in another way. An entirely new sort of landing gear for aircraft may be very useful, but smaller and lighter radio and electronic equipment means more payload, and as more and more electrical equipment becomes necessary in aircraft—or in ships for that matter—so its weight and its bulk have somehow to be reduced.

'Now I shall venture onto rather thinner ice. The Institution is doing an immense amount of good. That I think is well established; but I believe also that it faces, with other Institutions of the same sort, certain dangers. It will be a very sad day for electrical engineering if this Institution ever becomes a mutual-admiration society. Any self-satisfaction or complacency and the whole



The silver-gilt scroll holder

The scroll holder was designed and made by Gerald Benney and was engraved by T. C. F. Wise. The engraving on the cylinder consists of the Duke of Edinburgh's cipher and a design symbolizing electrical engineering. On the base appear The Institution's coat of arms and the words 'This Certificate of Honorary Membership of The Institution of Electrical Engineers was presented to His Royal Highness The Duke of Edinburgh, K.G., P.C., K.T., G.B.E., F.R.S., at the Annual Dinner of The Institution, 23rd February, 1956'.

Photograph by the Worshipful Company of Goldsmiths

The President presents the scroll holder containing the Certificate of Honorary Membership to the Duke of Edinburgh at the dinner-table

Photograph by *Daily Herald*

profession will suffer. But there is perhaps an even greater danger. If The Institution ever loses sight of the hard facts of industrial and commercial life, not only the profession but the whole nation will suffer. The Institution may have no direct responsibility to industry, but it has a direct responsibility through its activities and through its members to the community as a whole, and it rests with The Institution to ensure that all the products of British electrical engineering are the best in the world.

'I give you the toast of "The Institution of Electrical Engineers" coupled with the name of its President, Sir George Nelson.'

The **President,** in response, said:

'I am sure like myself you are all most grateful for the nice things that His Royal Highness has expressed in his toast to The Institution, and that you will mark his warnings. They are very important, and I shall refer to them in a moment.

'This is the most important function in The Institution's year in that on no other occasion are so many members gathered together in one place. I should not like our guests to assume from that observation that members are more interested in dining than in other activities. On the contrary, it is merely that our interests and activities are so diverse and so many that dining is one of the few interests which is still of equal importance to all our members.

'This year our Dinner takes on an even greater importance from the presence to-night of His Royal Highness, and from the honour which he has done us in accepting Honorary Membership of The Institution.

'We regard ourselves as one of the battalions of that great army of scientists, technologists and engineers, who are exploring and exploiting the marvellous bounties of nature and who, in the words of Her Majesty's Christmas broadcast, "adventure on" to make the world a better place. I can assure you, Sir, that this is the philosophy of The Institution of Electrical Engineers, and it leaves no room for the complacency against which Your Royal Highness so wisely warned us. But I would point out that your wisdom has reached the sun, and although the sun has indicated its pleasure at this meeting to-night, it does emphasize what would happen to us if we did not take Your Royal Highness's advice with regard to complacency.

'During the recent tour of Her Majesty and Your Royal Highness you have been in our prayers and we are delighted that research and development in radio navigational aids have contributed to your safe flights, and that modern developments in telegraphy, radio-communication and telephotography have enabled news and pictures, and particularly the joy of the people of Nigeria at Her Majesty's visit, to be brought to us here almost simultaneously with the actual events.

'In ancient times high levels of culture and civilization were reached but were enjoyed by relatively few people, whose high standards were maintained by the efforts of countless slaves. What a change to-day, when everybody participates in the benefits of civilization through the Aladdin's genie—or should I call it Faraday's genie—of electricity which has improved the lot of millions of people and has brought the countries and peoples of the world closer together.

'As our civilization further develops and expands, tastes will almost certainly become more and more sophisticated, bringing increasing demands for electrical equipment in houses and factories to ease the burden of man and to cheapen the cost of production, and for medical equipment to bring better health and longer life. Millions of horse-power are already being generated from coal, oil and hydro-electric sources for this purpose, and to this, as Your Royal Highness has said, will be added at not too distant a date, power generated from nuclear energy, although I appreciate that we must not expect it too soon.

'Millions of people to-day take for granted the benefits of electric power and do not fully realize that its generation is steadily bringing about the exhaustion of fossil fuels such as coal and oil. It is really, as Your Royal Highness indicated, bad economics to burn oil and coal, but it was the best method of producing electric power that we have had available in the past before nuclear power came in sight; now this development must be urged on with all speed. This Institution has formed, with other Institutions concerned—and some of their Presidents are with us to-night as guests—a joint Conference to co-ordinate efforts in pressing on this vital development. Although nuclear energy will provide an alternative to fossil fuels, our scientists will also have to find substitutes for many other basic materials which are being consumed at an ever increasing rate, as the standard of living of the people of the world advances. This confirms Your Royal Highness's emphasis on the importance of research, but we must ensure that when the conjurer produces elephants they are not white ones.

'These developments demand an increase in the numbers of scientists and engineers, as you, Sir, have said, to develop and to bring these essential new sources of energy and raw materials into production in the future. The responsibility for producing this increased supply must be borne by our universities and colleges of technology in collaboration with industry through appropriate changes in elementary and secondary schools. The necessary resources to fulfil this great responsibility must be provided immediately.

'Boards of study must not for one moment consider that their responsibility is limited to producing men trained in science and engineering. They must go much further and establish courses that will produce men who have acquired an awareness of their responsibilities to the community, and whose powers of judgment and initiative are adequate for their tasks. Our success, our survival as a great nation and, I might say, the future of the British Commonwealth, to which Your Royal Highness referred, depend on this increased supply of trained men with the ability to solve problems at all levels. Not only must we ensure an adequate supply of trained men, but we must also ensure that when they enter research establishments and industry, the most efficient use is made of their services and that their efforts are not inhibited by administrative defects.

'In fields under the control of Government departments much waste of technical man-hours arises through the application of the annual budgeting system to long-term projects of development and production. Also in industry, in answer to calls for more competition, there is developing the multiplication of technical efforts on developments of a similar nature. Competition is undoubtedly good in principle, but not if it reaches the stage where it causes waste of scientific and technical resources of the country.

'Your Royal Highness, in conclusion I again thank you most sincerely for having proposed the toast of "The Institution", for your interest in science and engineering and for your presence here to-night, which inspires us to live up to the dedicated example which you have set and to go forward to our future tasks with hope, optimism and enthusiasm.'

Mr. J. Eccles, Immediate Past-President of The Institution, in proposing the toast of 'Our Guests', said:

'It is a curious custom of civilized societies that they often invite guests mainly to do honour to themselves. To-night it is my privilege to welcome all those who have honoured us in this way.

'May I begin with a masterpiece of understatement by saying that our principal guest is already well known. We know him as an inspirer of thought and action in many spheres—one who realizes that a leader should never be so far ahead as to be out of earshot of the troops. We know him as one who appreciates the value of applied science and, I am very glad to say, the value of scientists. We know him also as a master of the spoken word and as a protagonist of the short after-dinner speech. All this, Sir, will be counted unto you for righteousness by engineers, whose main business in life is to get things done without fuss.

'To-night, Sir, as our President has said, you have honoured us in a very special way by accepting the Certificate of Honorary Membership. Henceforward you are one of us. Before you, you see a three-per-cent sample of the 40 000 members of your Institution. I trust that this close-up will not leave the same impression as the inspection of his troops left upon the Duke of Wellington, who is reported to have said: "I don't know what effect they will have upon the enemy, but by Gad, Sir, they frighten me."

'To restore your confidence, Sir, I should like to allude to the Senior Service and to suggest that these are the Argonauts of applied science, and under your inspiration may we not yet find the Golden Fleece of industrial prosperity? We are deeply grateful to Your Royal Highness for coming amongst us to-night at what must have been considerable inconvenience so soon after the very successful, but extremely arduous, Royal Tour of Nigeria. May I be permitted to use a familiar phrase and say, "We are delighted to have you back"?

'We have other guests also. Guests, unlike stars—and by stars I mean those heavenly bodies with fairly fixed habits—guests, unlike stars, do not pale into insignificance in the presence of a greater or a nearer source of

light. We therefore welcome all our distinguished guests in their own right.

'Although we have now escaped from the thraldom of the million-listener class, my time is rationed by instruction and example. I cannot possibly mention everyone by name; but I hope that in the generalizations that I am now about to make each will recognize a personal greeting somewhere.

'First of all I welcome Your Excellencies, the Ambassadors of other states. I am afraid that in spite of what His Royal Highness and the President said, our telecommunications branch is rather in the dog-house with the Diplomatic Corps, because nowadays the news is received in every capital before the smoke has died from the pistol that fired the fatal shot. In that sense diplomacy is no longer a training ground for the writing of detective stories. I am afraid I cannot promise Your Excellencies any respite in this matter. In fact, to-night you are in the lion's den because, as has already been said, have we not here Dr. Kelly and Sir Gordon Radley, fresh from their triumphs in laying the first half of the transatlantic telephone cable? In spite of all that I have said, I am certain that we all wish them well in their effort to complete the second half. Be all that as it may, diplomacy still has its main and greatest role to fill, that is the interpretation of mind to mind and the explanation of motives and intentions on a friendly and personal basis. It is as peacemakers in a very real sense that we welcome here this evening the very distinguished representatives of other states.

'We welcome also the Ministers and representatives from all the countries of the Commonwealth. The Commonwealth—that great group of free and equal states in which Kangaroos play cricket, Springboks and Kiwis, an odd combination, play rugby football, the Mohawks play ice hockey, and we, at home, seem to spend most of our time in trying to raise a team which will draw with—never mind defeat—the Moscow Dynamos. How pleasant it is to see the newer members of this great family emulating us in these pastimes and adding to our common heritage the stability and strength of their ancient cultures. We welcome them all here to-night.

'From Ministers of the Commonwealth to Ministers of the Crown—we welcome Her Majesty's Ministers and the other Members of both Houses of Parliament. Her Majesty's Ministers bear for us the burdens of pilotage of our affairs through the channels of a distraught and sometimes angry world. All that we can do to-night is to thank them for what they do for us, to give them a meal and a glass of port to fortify them for further effort on our behalf. Members of Her Majesty's Opposition will see that they do not rest too long upon their laurels.

'Next I should like to welcome distinguished representatives of the permanent Civil Service. These are the people who interpret policy and who, despite kaleidoscopic changes, manage to serve it up as though it contained all the old ingredients plus a little something that some others hadn't got. We welcome these pillars of stability and emblems of continuity.

'Policy—interpretation of policy, execution of policy—surely that brings me to our remaining guests. They are representatives of the great educational institutions and professional bodies, of the fighting services and the public services, of the Church, the Law and the "Profits", and of the Press. These are our kith and kin, those who toil and spin to make a better world for themselves and for others. Seriously, they are the people upon whom we shall have to depend for our survival and for the advance towards social betterment, which we all desire. We offer them the warmest welcome.

'I have left until the end the name of one with whom I wish to associate this toast—Sir Cyril Hinshelwood, President of the Royal Society.

'The Royal Society has its origin somewhere in the mists of antiquity. In about 1645, I am told they met for the first time weekly in London to discuss scientific affairs. In 1662, they received a Royal Charter from King Charles II; they survived the Plague, the Great Fire and a period of residence in Fleet Street. Their record must be unique in the wealth of scientific talent embraced within their membership during the past 300 years, and in the manner in which and the extent to which they have sponsored and financed the pursuit of scientific endeavour throughout the world.

'Sir Cyril is the latest of a long line of distinguished Presidents and to him, with Sir David Brunt, has fallen the task of organizing the British participation in the surveys and recordings to be undertaken during the International Geophysical Year 1957. Up till now he has been a model President. He has not uttered any of those calculated indiscretions that seem to be the prerogative of Presidents of another royal place. We welcome you, Sir Cyril, and thank you most warmly for consenting to respond to this toast.

'I have tried to keep my speech as short as possible consistent with my duty. We are indebted to a famous Judge for a definition of a short speech. He said that it was the same as the definition of a short lease in the Finance Act of 1940, which runs, "A short lease is a lease that isn't a long lease".

'If, in the interests of brevity, I have omitted to mention or to cover by implication any of our guests, may I here and now include them by saying very simply and very sincerely we are pleased and grateful that you have been able to come.

'Your Royal Highness, Mr. President, Ladies and Gentlemen, I invite all Members of The Institution to join with me in honouring the toast of "Our Guests", coupled with the name of Sir Cyril Hinshelwood, the President of the Royal Society.'

Sir Cyril Hinshelwood, President of the Royal Society, in response, said:

'On behalf of my fellow guests and myself I thank you for drinking the toast which you have just drunk, and for inviting us here to-night on this memorable occasion, when we are all so much honoured by the presence of His Royal Highness.

Photograph by *Daily Herald*

The High Commissioner for Australia with the Duke of Edinburgh, who holds the Roll of Honorary Members, which he is about to sign

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'I am glad to have the privilege of replying if only because it affords me the opportunity of widening the issue a little. I do not mean that I am going to respond to the invitation, or near invitation, of your Past-President to commit a "calculated indiscretion", although I am glad to learn from his remarks that none of my uncalculated indiscretions has appeared in that light to the world so far.

'As your Past-President has said, your guests to-night are of many different callings, but we are all united, I think, in our indebtedness to your profession of electrical engineering. That is not surprising because, after all, you control what is probably the most fundamental of all the forces of nature. We are literally made of electricity, are we not? Our brains are complex electrical calculating machines and when they go wrong, as they do sometimes under the stress of modern life, the doctors who deal with them have themselves to be something of electrical engineers to put them right. Then, even if we have no brains to go wrong, we have television sets. There again we are equally dependent upon you.

'Some guests to-night are, from your point of view, laymen and some are scientists who perhaps are not, from that point of view, quite so much laymen, although more nearly laymen than other laymen might think. We are all equally dependent upon you. If scientists really did their jobs properly I believe they would all have to be electrical engineers now. I remember the chairman of one of our most important chemical companies, after visiting my laboratory some time ago, said rather sadly, "You know, when I used to come to your laboratory years ago I saw interesting fundamental chemical experiments, and now what do I see? Electronics, electronics and more electronics everywhere. It is very deplorable." I said that it was not deplorable, that it was a sign of the times and that it was all right, but it does illustrate that we are all, or should be or try to be electrical engineers, and we are very dependent upon you.

'When one is visiting one's friends one of the attractions is to be moved to a certain degree of envy by the visit; their gardens always seem better kept than our own, and they have made better finds in the antique shop than we have; and so it is when we are your guests. I think we are moved a little to envy you. To the pure scientist (if I may use that horrible phrase), dealing with the fundamentals of nature, it does sometimes appear that the further he goes the more things dissolve into abstractions. The fundamental laws of physics are such that to cope with them you need, like the White Queen in *Alice*, to manage to believe six impossible things before breakfast every morning. But although the fundamentals dissolve into nothing and one cannot believe that anything can come of it, nevertheless the applications which are chiefly in your hands become more and more remarkable, more and more valuable, even more and more commercially exploitable, and are in every way so real that even Dr. Johnson, rapping the stones of Fleet Street, could not have asked for anything more solid. So we really do envy you in that respect. You are in touch with reality, demonstrable and unquestionable reality—the reality of every day which is inescapable and important.

'You are, of course, a very up-and-coming modern lot. It is nice for the guests to feel that they are on good terms with people who can control such powerful ju-ju. I hope I have used the term correctly, for His Royal Highness has doubtless seen the real thing at close quarters lately. It makes us feel good to know the right people. I expect you remember that little story of the business man who was about to address the schoolboys on the qualities which make for success in life. He was an opportunist like many successful business men, and his eye was caught by a notice on the door of the classroom when he entered. It read "Push", and he went in and said, "Boys, the thing that will bring you success in life is inscribed on the door of this room". Their eyes immediately wandered to the door and the only notice which they saw was "Pull". They were not surprised. Boys are much more worldly wise than is generally thought by their elders. I have never been in a position, I am afraid, to make very much use of pull myself, but there it is. However, I do feel that perhaps one is getting on the right road when one is invited to dine with The Institution of Electrical Engineers.

'One *is* on the right road, although that is wrapping up a profound truth in a frivolous manner. Those of your guests who are scientific by profession and those who are not do realize what an enormous amount the members of your Institution contribute both to knowledge and to the national well-being, and we are most grateful to you and most honoured that you should have drunk our health. Thank you very much.'

SHORT REVIEWS OF PAPERS

On the following pages are some brief articles based on, and written by the authors of, current Institution papers (including Graduate and Student Section papers). The authors have been asked to make these articles, so far as possible, of appeal to electrical engineers who have no specialized knowledge of the subjects, and the content of the articles is not necessarily confined to the subject-matter of the original papers.

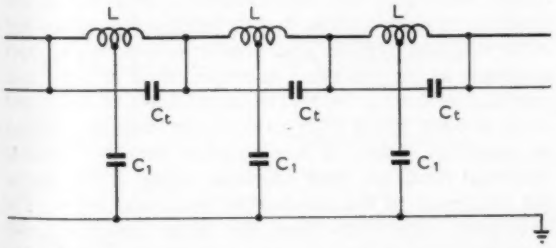
Surge Voltages in Electrical Machines

A short review of two Supply Section papers (Nos. 1997 and 2018) entitled 'The Penetration of Surge Voltages through a Transformer Coupled to an Alternator', and 'The Propagation of Surge Voltages through Turbo-Alternators with Concentric-Conductor-Type Windings', by B. C. Robinson, M.Sc., Ph.D., Member. The papers were published individually in February, 1956, and they will be republished in Part A of the Proceedings.

THE USE OF OVERHEAD LINES TO TRANSMIT ELECTRICAL power caused engineers to study the various types of over-voltage which occurred in the systems. Sometimes these over-voltages were traced to lightning strokes in the neighbourhood of the lines. The earliest investigations were mainly theoretical owing to the lack of experimental techniques to measure the voltages, and precise measurements were begun only with the development of the cathode-ray oscillograph.

Transformer Windings

The majority of the investigations have concentrated on transformer windings, owing to their greater fault-incidence rate. The first complete solution to the problem of surges in a transformer coil was given by Blume and Boyajian in 1919, who derived a series of partial differential



1 *Equivalent circuit for a single simple transformer winding*

equations relating the current and voltage in a single coil, which is assumed to possess inductance, capacitance to earth and capacitance between coils as shown in Fig. 1.

When an infinite rectangular voltage wave is applied to the terminal of the winding Blume and Boyajian showed that the resulting voltages could be expressed as a number of harmonic waves which oscillate in both time and space. The frequencies of these oscillations depend on the winding parameters, the neutral-point termination and the winding length. Because of this latter dependence, this particular type of solution has become known as the *standing-wave solution*. It may in fact be likened to the much simpler problem of the oscillations in a string vibrating between two fixed supports. This theory has been further developed by various workers.

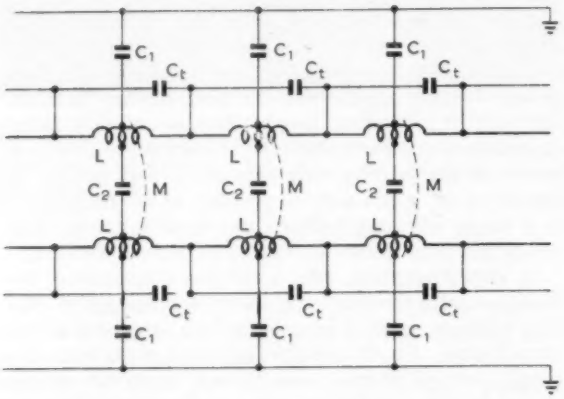
In 1940 Rudenburg gave a different derivation of the fundamental differential equations and suggested that their solution could be represented by a simple travelling-wave system. He treated the incoming wave as a full-range Fourier integral, and showed that the various sinusoidal components enter the winding, and that those whose frequency is less than a certain critical value f_c are propagated as travelling waves with a velocity which is an inverse function of the frequency. This variation of velocity with the frequency of the sinusoidal components produces a travelling wavefront which increases in length with the distance travelled. This travelling wave is then reflected at the ends of the winding according to the normal rules governing the reflection of travelling waves. The components of the incident wave which have a frequency greater than f_c are shown to produce at the beginning of the winding a capacitively distributed standing voltage, which dies away exponentially with time. (Unfortunately Rudenburg's paper contains an erroneous derivation of the intercoil voltages in the transformer.) Owing to its emphasis on travelling waves, this treatment has become known as the *travelling-wave theory*. It does appear to provide the student with an approach which is easier to visualize than the standing-wave solution.

This travelling-wave theory has been further developed by Makin, who suggests the use of a half-range Fourier integral for the applied wave, thus avoiding some difficulties which arise when visualizing the initial conditions with a full-range integral. Also, he shows that in a transformer with two separate windings, two sets of travelling waves are produced in each winding, the characteristics of one wave in each set being determined by the parameters of each winding.

A.C. Generator Windings

Comparatively little work has been published on generator windings, probably because of their much lower rate of incidence of faults due to lightning surges. It was generally considered that a generator would behave like a length of transmission line having high inductance and capacitance. Calvert and others also introduced the self-capacitance, between turns in coils, giving an equivalent circuit similar to that in Fig. 1, but did not develop the mathematical theory.

The author has previously suggested* that an alternator should be treated as a two-winding transformer with two similar windings. This produces an equivalent circuit like that in Fig. 2, where the two windings are linked by

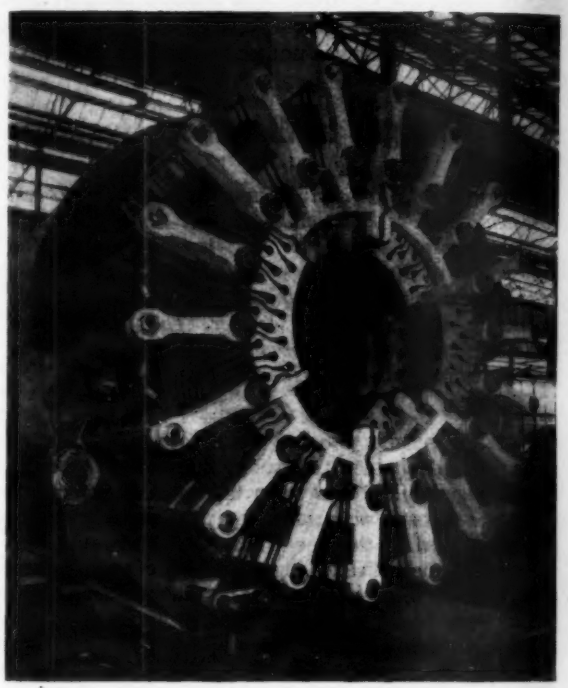


2 *Equivalent circuit for a conventional generator winding*

capacitance and mutual inductance, since the flux linkages round the two conductors in a slot of a large alternator are bound to be considerable. Owing to the arrangement of the coils in an alternator, however, the two conductors in a slot do not run consistently from slot to slot together. This does not invalidate the calculations but renders the mathematics more difficult to interpret.

The theory indicates that there are two sets of travelling waves in the winding. There are also two theoretical critical frequencies for the winding, and for each component frequency below the lower critical frequency there are two velocities of propagation as determined by the winding parameters. For frequencies above the critical frequency the winding behaves as a capacitor. Tests on the above machine indicate that only frequencies below the first critical frequency affect the voltage distribution in the windings.

The concentric-conductor turbo-generator has the winding of each phase divided into three sections. The conductor bars are circular and have three conductors arranged concentrically. The central or bull conductors of the conductor bars of each phase are connected in series, and are then connected to the middle or inner conductors, which are connected in turn to the outer conductors. The same construction is applied to the other two phases. The voltage across each layer of insulation is thus only one-third of the total machine voltage. This enables a considerable economy to be made in the amount of insulation required. The end windings of a typical machine are shown in Fig. 3.

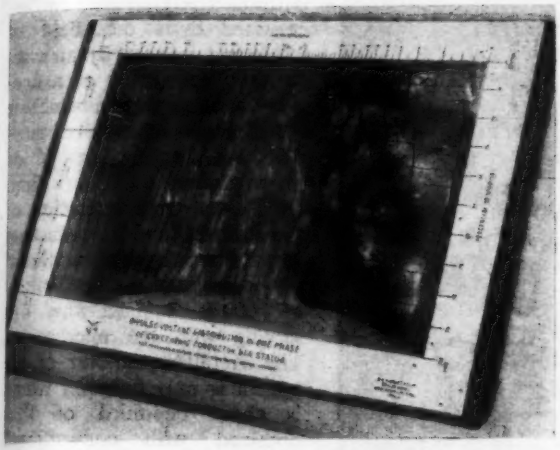


3 *A typical 33 kV concentric-conductor generator stator*

In the theory of impulse-voltage distribution, the three sections of the winding are assumed to be coupled by mutual inductance and inter-conductor capacitance. The resulting equations show that the application of a surge to the machine terminal (bull conductors) causes voltages to appear in the conductor bars concerned between each pair of conductors, i.e. bull to inner, inner to outer, and outer to core. These voltages travel through the winding as travelling waves in a manner similar to the conventional machine, their velocities being dependent on the frequency of the component sinusoidal waves. For any given frequency there are three velocities, each characteristic of the two conductors concerned. The system is simplified, however, by the fact that only one set of waves is set up initially between a pair of conductors, though the number increases rapidly through reflections at the links between the various sections of the winding and at the phase terminations.

Fig. 4 shows a three-dimensional model giving the

* Robinson, B. C.: 'The Propagation of Surge Voltages through High-Speed Turbo-Alternators with Single-Conductor Windings', *Proceedings I.E.E.*, Paper No. 1561 S, October, 1953 (100, Part II, p. 453).

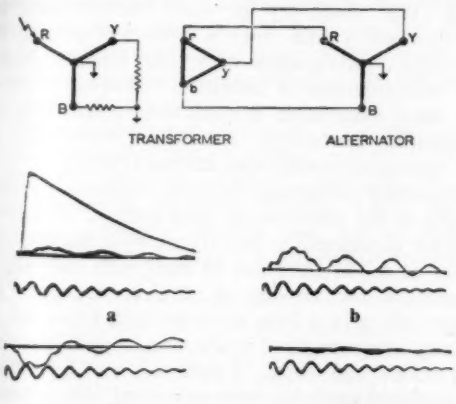


4 *Three-dimensional model showing impulse-voltage distribution in one phase of a concentric-conductor generator with the neutral point earthed*

voltage distribution as a function of both time and winding length.

A Generator connected to a Transformer

It is now common practice to connect a generator having a terminal voltage of about 11 kV solidly to a transformer, which steps up the voltage to 66 or 132 kV before connection is made to the external system. Such an arrangement must be treated as a whole when considering its response to an impulse voltage. Tests indicate



5 *Oscillograms of voltages at the transformer and generator terminal*

(*a*) Transformer h.v. terminal phase R and generator terminal phase r.
(*b*) Generator terminal phase R.
(*c*) Generator terminal phase Y.
(*d*) Generator terminal phase B.

Oscillograms (*b*), (*c*) and (*d*) were recorded with an increased impulse voltage compared with oscillogram (*a*).
Impulse voltage wavetail: 40 microsec.
Oscillator frequency: 100 kc/s.

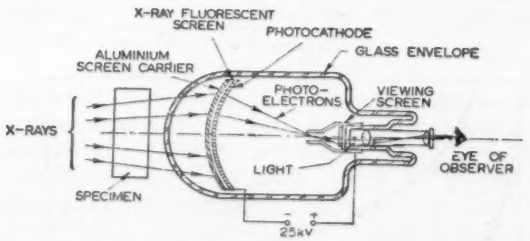
that when a surge voltage is applied to one or more terminals of the transformer the resultant phenomena may be divided into two sections. First a series of travelling waves is set up in the transformer windings as previously discussed. The voltages transferred to the l.v. windings also set up travelling waves in the alternator windings. Secondly, and of greater importance, the lower-frequency components in the surge set up a flux in the transformer limb and cause an oscillatory voltage to appear across the transformer l.v. terminals. The frequency of this oscillation appears to be governed by the transformer inductance and by the equivalent capacitance of the generator and its connecting cables, while the magnitude of the induced voltage seems to be governed by a factor which can be approximately represented by the surge impedance of the generator. The experimental test circuit and oscillograms of the applied voltage and of the voltage at the three alternator terminals are given in Fig. 5. The ripple which appears on the main low-frequency oscillation is due to reflections of the travelling waves in the windings. It should be noted that the oscillograms showing only the alternator-terminal voltage were taken with a greater applied voltage than that showing the applied impulse voltage and the voltage on phase R.

621.314.2 : 621.3.015.33 : 621.313.322.045

Brighter X-Ray Images

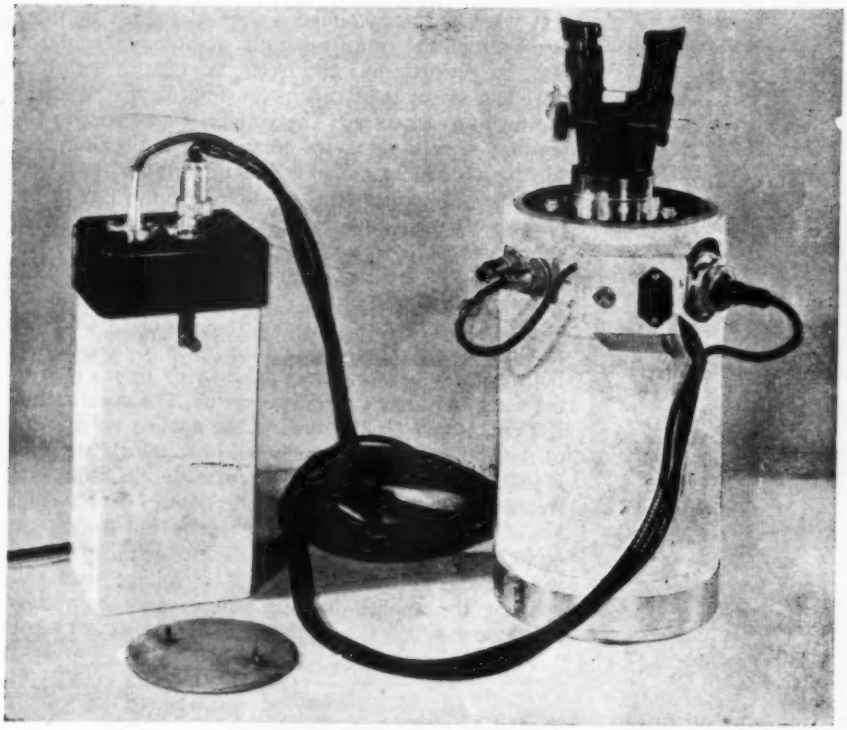
A short review of a Utilization Section paper (No. 1881) entitled 'Intensification of the X-Ray Image in Industrial Radiology', by A. Nemet, Dr.-Ing., F.Inst.P., Member, and W. F. Cox, B.Sc. The paper was published individually in July, 1955, and it will be republished in Part B of the Proceedings.

IMAGE-INTENSIFYING X-RAY TUBES ARE WELL KNOWN TO the medical radiologist by now. In industrial radiology, the intensifier tube has advantages which should make many X-ray examination processes more economical and



1 *Intensifier tube: diagrammatic view*

are likely to lead to new applications which are too costly with conventional methods. Such a tube (Fig. 1) consists of an image convertor transforming the fluorescent image produced on the X-ray screen into an electron

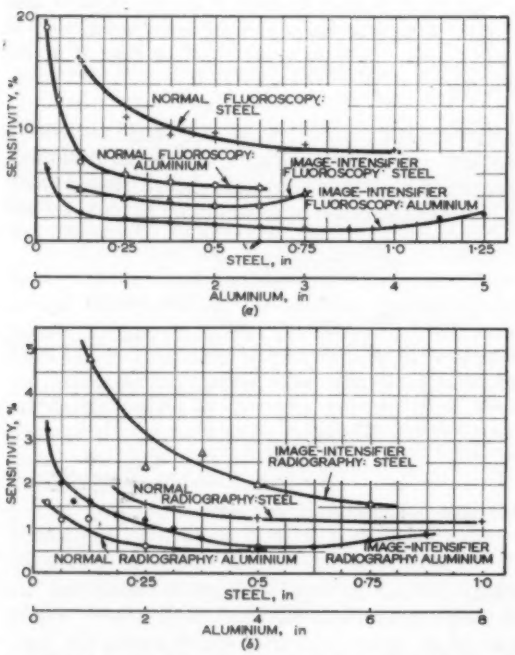


2 *Intensifier tube fitted with binocular microscope*

pattern. The electrons are accelerated by a d.c. field of 25 kV and focused by an electrostatic lens system on a fine-grain viewing screen, which is either observed through a binocular microscope (Fig. 2) or photographed on 35 mm film. Owing to the acceleration of the electrons and the reduction of the image by a linear factor of 9, a brightness intensification of 1 000 is obtained when observing with the microscope. The overall screen-blur of the system is only 0·3 mm, which is about one-third of that obtained with conventional X-ray screens.

When photographing the viewing screen there is considerable loss of light owing to the limited aperture of the lens. Even so, the exposure on fine-grain Microfile film is only of the order of 1 or 2 min with about half the X-ray tube voltage used in ordinary radiography.

Penetrameter measurements have been carried out with the D.I.N. wire penetrameter on aluminium and steel plates. The results show that in fluoroscopy, with the image intensifier, the sensitivity is much better than in normal fluoroscopy and only a little worse than in normal contact radiography with lead screens. Penetrameter measurements in miniature radiography show that the detail observable is somewhat better than in image-intensifier fluoroscopy but rather worse than in ordinary radiography with lead screens (Fig. 3).



3 *D.I.N. sensitivities in fluoroscopy (a) and radiography (b)*

An interesting advantage in both fluoroscopy and radiography is the reduction of tube voltage. In fluoroscopy 125 kV is sufficient to penetrate a $4\frac{1}{2}$ in thickness of aluminium or a $\frac{1}{2}$ in thickness of steel with only slight eye adaptation for viewing in dim room light. In radiography the gain is even more marked, exposures of 40 sec being adequate for 7 in aluminium and $\frac{3}{4}$ in steel plates at 125 kV and 4 mA. Examination of light-alloy castings and steel welds has been compared with penetrameter measurements and general agreement has been obtained. To obtain the best results the intensifier must be used with a fine focus tube and a magnification of 2. A limitation of the intensifier tube is its restricted screen size (5 inches).

Statistical quantum fluctuations of the incident X-radiation are clearly visible in fluoroscopy with the image intensifier. The limit of perceptibility is probably set by these fluctuations in most fluoroscopic examinations.

The most useful application is likely to be in fluoroscopy, which can now be used in place of radiography in many instances where a permanent record and highest sensitivity are not required. This eliminates film-processing costs and delay. Also, the specimen can be viewed in any direction, which is useful for crack detection. Where a permanent record is required but the highest sensitivity is not essential, photographs can be made on 35 mm film, which is much cheaper than full size radiographs. Another attraction of the image intensifier is that protection is facilitated by the softer radiation and the smaller X-ray intensity used.

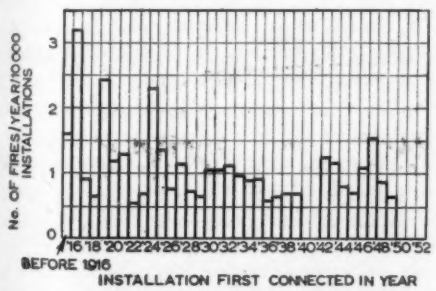
620.179.15 : 621.386.8 : 778.33

Electrical Fire Risks

A short review of a Utilization Section paper (No. 1938) entitled 'Age and the Incidence of Fires in Electrical Installations', by L. Gosland, B.Sc., Member. The paper was published individually in January, 1956, and it will be republished in Part A of the Proceedings.

ABOUT 9000 FIRES ARISE ANNUALLY IN GREAT BRITAIN from electrical causes. Rather less than one third of these are caused by defects in electrical installations, and there has been some concern lest this class of fire should increase rapidly in future, as the installations in the large number of houses wired during the period of rapid growth of electric supply become old. Accordingly, in 1947, the Committee on Fire Risks of the Electrical Research Association decided to seek an answer to the question of whether there was an age at which electrical installations, and particularly domestic electrical installations, might be supposed to have reached the end of their useful safe life. The paper describes and gives the results of a statistical investigation intended to provide an answer to this question.

The author reviews data on the occurrence of the 1100 fires attributed to defects in the fixed electrical installations of a population of about 2·5 million consumers in the years 1951 to 1953 inclusive. From the relation between incidence of fires and age of installations, illustrated in the Figure, it is shown that, for installations more than fifteen years old, the incidence of fires is roughly proportional to age. There is no clear evidence of any rapid incidence of fires after any specific age is passed, but the data available are insufficient to permit firm conclusions on this point. Installations less than fifteen years old are considered as a separate class, being subject to innovations in housing construction and installation practice.


No. OF FIRES/YEAR/10 000 INSTALLATIONS
0
1
2
3
BEFORE 1916
16 18 20 22 24 26 28 30 32 34 36 38 40 42 44 46 48 50 52
INSTALLATION FIRST CONNECTED IN YEAR

Incidence of fires due to defects in fixed electrical equipment: variation with age of installations

Incomplete data on the types of defective equipment and on the nature of the defects are reviewed. The particular sources and causes of fire examined are: defects in service equipment, defects in fittings and in fixed wiring, unauthorized, temporary and amateur wiring, fires due to defects in appliances, leakage to gas pipes, leakage due to moisture or heat, defective earthing, and bad contacts. There is no clear indication that any one type of equipment is particularly subject to the effects of age. The most frequent primary cause is a defect in wiring, and the most frequent secondary cause fortuitous contact between earth continuity conductors and composition gas pipes. Apart from the latter there seems no single type of defect whose elimination could lead to outstanding reduction in the incidence of fires.

Post-war installations appeared to suffer fires at a rate greater than would be expected from the experience with pre-war installations. This can be directly traced to an unduly large number of fires associated with fuses, fuseboards, distribution boards, control units and the like, probably mainly of early post-war design.

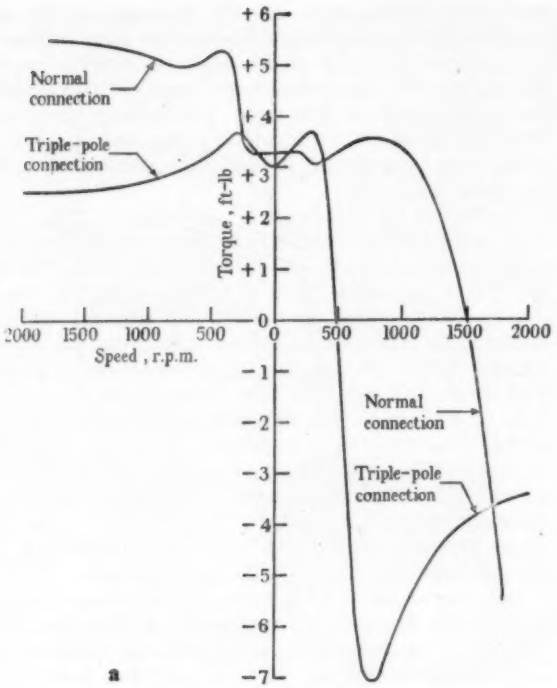
The shortcomings in the data on age of installations are pointed out, and the suggestion is made that an investigation more elaborate than the pilot survey described in the paper might give decisive information. 621.31 : 614.84

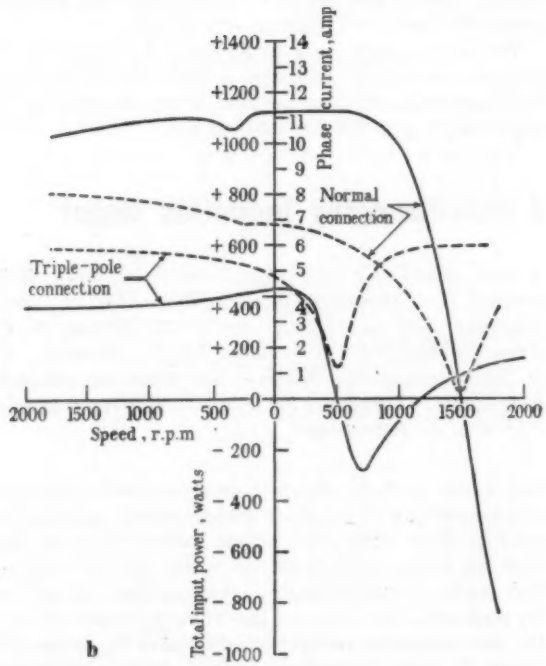
A Pole-Changing Induction Motor

A short review of a Utilization Section paper (No. 1951) entitled 'The Theory and Characteristics of the 3 : 1 Pole-Changing Induction Motor', by T. H. Barton, Ph.D., Associate Member, O. I. Butler, M.Sc., Member, and H. Sterling, Associate Member. The paper was published individually in December, 1955, and it will be republished in Part A of the Proceedings.

THE PAPER IS PRINCIPALLY CONCERNED WITH METHODS of reconnection of induction-motor primary windings to produce three times the original number of poles, and with the design of such machines, but it is pointed out that similar principles enable larger numbers of poles to be produced. The basis of the triple-pole connection is the zero-sequence connection, discussed by Butler and Brown.* This connection results in a single-phase excitation of the triple-harmonic field of the machine such that a synchronous speed of one-third normal is obtained. The connection has the disadvantages of all

* BROWN, J. E., and BUTLER, O. I.: 'The Zero-Sequence Parameters and Performance of Three-Phase Induction Motors', *Proceedings I.E.E.*, Monograph No. 92 U, February 1954 (101, Part IV, p. 219).





Normal and triple-pole characteristics

Normal characteristics at 90 volts/phase; triple-pole characteristics at 75 volts/phase.

(*a*) Torque/speed curves.

(*b*) Input power/speed curves ————. Phase current/speed curves — — — —.

single-phase connections, i.e. no starting torque and poor utilization of the windings. The connection proposed here comprises a number of such zero-sequence connected windings displaced in space relative to the third-harmonic field to form balanced polyphase triple-pole windings. The number of terminals required on the machine, and the number of switching operations to be performed when converting from normal to triple-pole operation, are not excessive.

The improvement in performance obtained by polyphase operation is considerable and a standard single-speed machine, when reconnected, gives a triple-pole torque performance of approximately half its normal torque performance. However, it is shown that, by adopting a design which is a compromise between the requirements for normal and triple-pole operation, the torque performances at the two speeds are comparable and are but little inferior to the performances of standard single-speed machines of equal frame size.

The diagram shows the experimentally determined characteristics of such a compromise design. The motor stampings are those of an 8-pole machine of 7·5 h.p. continuous rated output, although the rotor bars used were about two and a half times the normal resistance. This, together with the use of full-pitch primary windings, accounts for the large amplitude of the harmonic torques. Of necessity, the experimental results were obtained at reduced voltage, but they are directly comparable with those which would be obtained from the normal 400-volt supply.

The paper also discusses in detail a design method for predicting the triple-pole performance. This is based on the normal design method, and the relationships between triple-pole and normal parameters are established. The triple-pole performance, using this method, may be predicted with an accuracy comparable with that of prediction of the normal performance. 621.313.333

Applications of the 3:1 Pole-Changing Motor

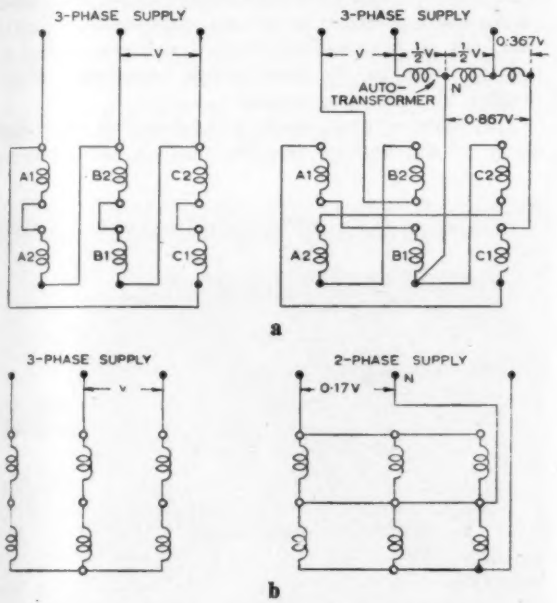
A short review of a Utilization Section paper (No. 2010) with the above title by T. H. Barton, Ph.D., Associate Member, O. I. Butler, M.Sc., Member, and H. Sterling, Associate Member. The paper was published individually in February, 1956, and it will be republished in Part A of the Proceedings.

A PREVIOUS PAPER* HAS DISCUSSED THE PRINCIPLE OF operation of the single-winding 3 : 1 pole-changing motor to obtain an output at each speed comparable with that provided by two separate single-speed motors of the same frame size. The present paper discusses the various

* BARTON, T. H., BUTLER, O. I., and STERLING, H.: 'The Theory and Characteristics of the 3 : 1 Pole-Changing Induction Motor', *Proceedings I.E.E.*, Paper No. 1951 U, December 1955 (103 A).

circuits which may be utilized in practice, and their sphere of application.

Primary circuits which operate on 3-phase star or delta connection at the higher speed and 3- or 2-phase connection at the lower speed are described, with particular reference to the need for minimizing the number of terminals whilst utilizing the winding to the maximum extent at both speeds. The transformer requirements for 2-phase operation can be reduced to a single auto-transformer, as shown in Fig. 1(*a*), of about

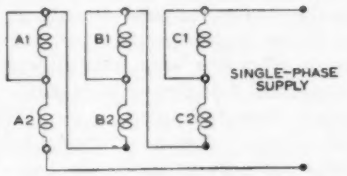


1 *Examples of 3-phase,* p*-pole/2-phase, 3*p*-pole connection*
(*a*) By means of a single auto-transformer.
(*b*) Star connected.
Patent No. 03845, 1955.

one-sixth the rating of the motor at full speed, and there is an appreciable reduction in the complexity of the winding connections and switchgear compared with those 3-phase/3-phase arrangements which do not require the use of a transformer. When a method of phase transformation is used the even simpler arrangement of Fig. 1(*b*) is obtained; the number of motor terminals has been reduced to seven, and the arrangement should prove to be particularly advantageous for small fractional-horse-power motors.

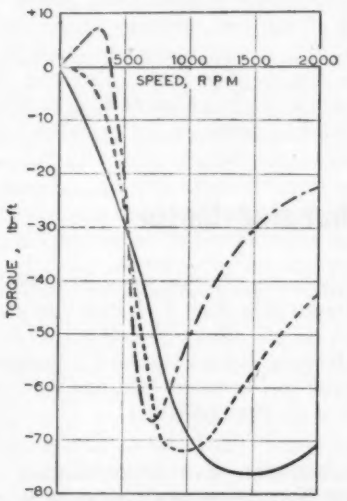
Brushless secondary circuits of the squirrel-cage type,* which provide widely different resistance characteristics at the two speeds, are considered. These rotors are likely to be of considerable value where a high efficiency at full speed is required and where a high resistance during triple-pole operation is desired in order to improve the regenerative braking efficiency or to make a.c. dynamic braking to standstill possible. This type of rotor may also be useful where the starting conditions are particularly arduous, since the motor accelerates to one-third speed with the minimum of losses and current.

Applications of the motor are divided into those requiring operation at either of two fixed speeds, and those in which the speed changes frequently between two or more limiting values. Examples of the former are the slow-feed and quick-return operation of machine tools during drilling, tapping, planing, etc., the positioning of



2 *3* p*-pole connection for equal positive- and negative-sequence voltage components*
Patent No. 03845, 1955.

the load at a reduced speed, as in lifts and machine tools, and either fast or slow running of reciprocating pumps and axial-flow fans for economical operation during periods of high and low demand. Examples of applica-



3 *Predicted torque/speed characteristics for the experimental machine with different values of secondary resistance and connected as in Fig. 2 to a 400-volt supply*
—·—·— $R_2 = 0{\cdot}5(X_1 + X_2)$
— — — $R_2 = 1{\cdot}0(X_1 + X_2)$
——— $R_2 = 2{\cdot}0(X_1 + X_2)$

tions involving frequent changes of speed are hoists, rolling mills and centrifuges.

The energy dissipation in the motor circuits is the most important characteristic of a speed-changing drive, whilst small motor inertia and low energy consumption are desirable characteristics. The various established

* Patent Application No. 00123, 1956.

methods of starting, stopping and reversing the drive are compared with that of the 3 : 1 pole-changing motor from the point of view of heating of the motor and it is shown that an appreciable reduction of the energy dissipation is obtained by dual-speed starting and regenerative-braking to one-third of full speed. In particular, provided that a mechanical brake is available to dissipate the residual 11·1% of the initial kinetic energy, the use of the 3 : 1 pole-changing motor is much superior to the use of d.c. dynamic braking. It is shown also that the 3-phase supply may be used directly as a slightly asymmetrical 3-wire 2-phase supply for speed-changing duty, with an efficiency very little different from that when a symmetrical 2-phase supply is used.

A.C. dynamic braking from full speed to standstill, with no possibility of reverse rotation, is obtained by the simple asymmetrical connection shown in Fig. 2, in which one phase of the 2-phase, larger pole-number winding is short-circuited. The braking torque at low speeds can be made small, even with a squirrel-cage rotor—a factor which finds favour in certain machine-tool drives in preference to d.c. dynamic braking and plugging. Fig. 3 illustrates the braking torque/speed characteristics of an experimental motor using the asymmetrical connection.

Many applications of the new machine are those for which the 2 : 1 single-winding pole-changing motor is used. A comparison of the two machines shows that only about 60% to 70% of the maximum respective single-speed outputs, for a given frame size, can be obtained with a 2:1 motor, whilst values of 80% to 90% can be obtained with a 3 : 1 motor. 621.313.333

A New Pole-Changing Motor

A short review of a Utilization Section paper (No. 1958) entitled 'The Development of a New 3 : 1 Pole-Changing Motor', by Professor G. H. Rawcliffe, M.A., D.Sc., Member, and B. V. Jayawant, B.Eng., Graduate. The paper was published individually in December, 1955, and it will be republished in Part A of the Proceedings.

ONE OF THE LONG-ACCEPTED WAYS OF PRODUCING A multi-speed a.c. motor is to change the number of poles by switching the connections, and the method of doing this, in the ratio of 2 to 1, is well known and widely used.

The aim of all pole-changing windings is to secure:

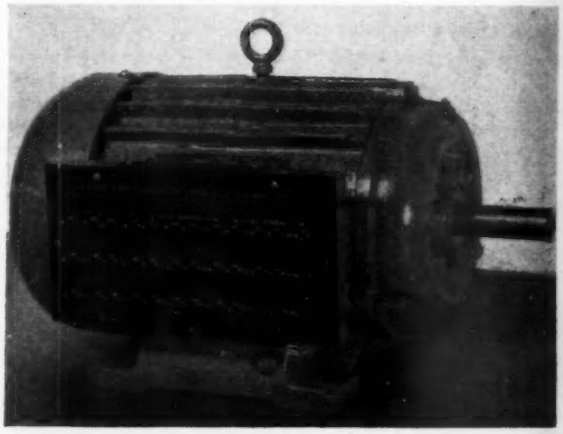
(i) High torque and power ratings at each speed.
(ii) Simple control arrangements.
(iii) Absence of crawling torques in each connection.
(iv) Windings which are easy to manufacture.

This paper describes a new winding,* giving a speed ratio of 3 to 1, which is excellent regarding points (i), (iii) and (iv), and satisfactory, though admittedly less than excellent, regarding point (ii).

* Provisional Patent No. 19001/55.

This machine is based on the principle that if the three phases of a normal induction motor, with full-pitch windings, are fed in series in the same sense, the number of poles formed is three times that which the winding would produce in normal operation. This principle has long been known, but the primitive winding so formed can be supplied only by single phase, and thus has no natural starting torque. Furthermore, if the machine is started by auxiliary means it gives very poor performance in both torque and power ratings for the frame concerned. Machines with various modified forms of winding, based on the above principle, have been proposed from time to time, but all have suffered from drawbacks, judged by one or other of the four criteria mentioned above, notably from crawling torques.

The authors have made an exhaustive theoretical study of the various possible winding modifications, particularly of the magnetic-flux waveforms produced by each, in order to establish the conditions for minimum crawling torques. All this theory is completely supported by full tests, on both light and full load, the results of which are recorded in the paper. The new form of winding described is believed to be superior to anything developed previously, and its only disadvantage is that it requires eleven leads between the machine and its controller, though this objection is probably more serious on paper than in practice.



Experimental 3:1 pole-changing motor

Whilst the machine designer is usually concerned with crawling torques only in the sense that he wishes to eliminate them, teachers of electrical-machine principles may wish to produce them in exaggerated form, so that the theory of complex rotating fields may be seen by students in action before their eyes. The experimental machine with the special terminal board used in these tests is shown in the photograph, and it will be seen that the winding is broken up into eighteen sections—one coil per pole pair of the original machine. This permits

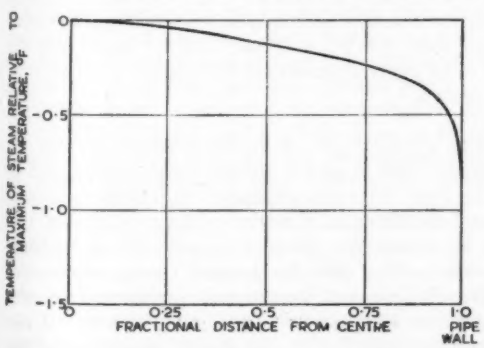
all the possible variations of 3 : 1 pole-changing connections, suitable and unsuitable, to be readily obtained by simple reconnection of the terminals. It is thus possible to produce a wide variety of crawling harmonics of varying orders and magnitudes, some rotating backwards and some forwards relative to the fundamental. Theory and practice are in close accord throughout, and a brief discussion is given in the paper of these unuseful but elegant effects, as well as of the particular winding which proved satisfactory in practice.

Very many applications have been found for induction motors of 2 : 1 speed ratio, largely, it is thought, because machines of this type have been known to be available; and it seems likely that once the existence of a winding of proved performance giving a 3 : 1 speed ratio is known it will find many applications also. 621.313.333

Steam Temperature Measurement

A short review of a Supply Section paper (No. 1872) entitled 'The Measurement of Steam Temperatures in Power Stations', by D. H. Lucas, B.A., Associate Member, and M. E. Peplow, B.Sc., Graduate. The paper was published individually in June, 1955, and it will be republished in Part A of the Proceedings.

THE MEASUREMENT OF TEMPERATURE MAY BE THOUGHT TO be one of the easier class of scientific observation—well understood for a long time and not subject to serious errors even in workaday practice. However, there have been mysterious cases of steam passing along an unheated pipe and emerging hotter than it went in; there have been numerous conflicts between technical men about objective measurements which disconcertingly obeyed subjective predilections, and, as in many other kinds of measurement, the greater the initial appearance of simplicity the greater has been the final conviction of complexity.



Temperature across a well-lagged steam pipe at 775° F and a mass flow of 152 × 10^3 lb/ft²-h

Radial heat flow: 173 B.t.u./ft²-h

For a different radial heat flow multiply figures on *y*-axis by $\frac{\text{Heat flow}}{173 \text{ B.t.u./ft}^2\text{-h}}$

For a different mass flow multiply figures on *y*-axis by $\frac{152 \times 10^3 \text{ lb/ft}^2\text{-h}}{\text{Mass flow}}$

This paper is an attempt by the authors to reveal and resolve the inherent difficulties of steam-temperature measurement by using, as far as possible, mathematical methods and existing knowledge of fluid flow and heat flow, and expressing the results in a way convenient to the testing engineer.

Errors may occur in steam-temperature measurement because of the incomplete mixing of steam from different sources. There appears to be no general agreement among steam engineers as to how rapidly steam mixes or indeed whether it mixes at all. It is shown in the paper that mixing can be considered complete in a length of 30 diameters of straight pipe, and that it may be accelerated by bends and constrictions.

Again, the uniformity of the temperature of the steam in a pipe has been a subject of controversy. The paper shows that at high steam flows and with a well-lagged pipe the steam temperature is sensibly uniform (see the diagram) but that with unlagged pipes and low steam flows there will be appreciably lower temperatures near the pipe wall.

The steam, the pipe wall, its lagging, the thermometer pocket, the thermometer and the outside air form a complex thermal network, and upon its nature and dimensions the actual reading of the thermometer depends. The results of analysing this network under typical conditions are shown in a series of curves in the paper. The authors include information on the quantitative effects of lagging the steam pipe, of increasing the length of the thermometer pocket subjected to the live steam, of having higher steam velocities and of using materials of higher thermal resistance for the pocket and the thermometer stem, so that in any given combination of circumstances the thermometer error can be estimated. Steam temperature can be measured very accurately without undue difficulty under most conditions, provided that the steam temperature is constant.

If the steam temperature is varying rapidly it is impossible to avoid appreciable errors without immersing the thermometer itself in the steam and forgoing the use of a pocket. This has been done successfully in experiments to verify the theoretical predictions, but it is doubtful whether the risks and difficulties associated with immersed thermometers will often be justified by the additional accuracy they yield. 621.182.27 : 621.311.22 : 536.5

An Ultra-High-Speed Oscillograph

A short review of a Radio and Telecommunication Section paper (No. 1931) with the above title, by F. R. Connor, M.Sc., B.Sc.(Eng.). The paper was published in March, 1956, in Part B of the Proceedings.

ONE OF THE PROBLEMS TO BE STUDIED IN CONNECTION WITH pulsed magnetrons is the build-up of oscillations, and

an oscillograph was designed to assist in this study by displaying the actual radio-frequency oscillations on a cathode-ray tube.

The oscillograph consists essentially of a triggered pulse generator, a constant-current type of linear time-base with a sweep of 2 millimicrosec, and a push-pull X-plate amplifier. Owing to the high frequencies to be examined (about 3 000 Mc/s), a special-purpose cathode-ray tube is used. The Y plates are made in the form of a short-circuited transmission line, to overcome transit-time distortion and to reduce plate capacitance. Moreover, the line construction provides a means of matching the signal at the plates. To assist in the visual examination of various parts of a waveform, short lengths of 70-ohm coaxial cable are provided for delaying either the start of the time-base or the signal being examined.

A further feature of the oscillograph is the calibrator, which is a pulsed 30-cm coaxial-line oscillator. Calibration is done by means of a sine wave, the frequency of which can be determined accurately by a wavemeter. Moreover, the linearity of the time-base can be checked by observing the spacing of the sine wave. 621.317.755

SYNOPSES OF PAPERS

The following are synopses of papers published in the *Proceedings* without first being read at an Institution meeting which have not been described elsewhere in the *Journal*.

Slot Radiators

A synopsis of a Radio and Telecommunication Section paper (No. 1930) entitled 'An Investigation of Slot Radiators in Rectangular Metal Plates', by D. G. Frood and J. R. Wait. The paper was published in January, 1956, in Part B of the Proceedings.

THE RADIATION FROM SLOTS CUT IN CONDUCTING SURFACES of limited extent is discussed. Equatorial plane patterns of an axial half-wave slot in a rectangular metal plate are measured in the X band. The experimental results compare favourably with the calculated patterns on the assumption that the plate can be represented by a thin elliptic cylinder or ribbon of infinite length. It is observed that, if the length of the plate is equal to or greater than its width, the pattern is within a few per cent of the corresponding theoretical pattern for a plate of infinite length.

The admittance of the slot in the plate was also measured and compared with the computed conductance. The agreement is seen to be quite good. 621.396.677.71

Microwave Filters

A synopsis of a Radio and Telecommunication Section paper (No. 2001) entitled 'Design of Microwave Filters with Quarter-Wave Couplings', by G. Craven and L. Lewin, Associate Member. The paper was published in February, 1956, in Part B of the Proceedings.

RESONATOR DIAPHRAGMS ARE CONSTRUCTED FROM TRIPLETS of inductive posts, whose spacings and radii are chosen to prevent the generation of the first five non-propagating modes. This is sufficient to ensure negligible coupling at quarter-wave separation. Measurements on filters at 4 000 Mc/s indicate a satisfactory performance.

621.372.54 : 621.372.8

Impedance of Transmission Lines

A synopsis of a Radio and Telecommunication Section paper (No. 1961) entitled 'Non-Uniform Transmission Lines as Impedance Transformers', by J. Willis, B.Sc.(Eng.), Associate Member, and N. K. Sinha, B.Sc.(Eng.). The paper was published in February, 1956, in Part B of the Proceedings.

THE EQUATION FOR THE REFLECTION COEFFICIENT AT ONE end of a non-uniform transmission line matched at the other end is considered, and an approximate form of solution is suggested which enables such lines to be designed for optimum performance as matching sections. A number of examples are calculated, and the results are compared with lines previously described in the literature.

621.372.22 : 621.314.2.029.5

Power Stations and Their Equipment

A synopsis of a review of progress paper (No. 1954) with the above title, by V. A. Pask, C.B.E., M.I.Mech.E., Member. The paper is published this month in Part A of the Proceedings.

THIS PAPER CONSTITUTES AN AUTHORITATIVE REVIEW OF the progress made in power-station development, and it should be read by every engineer interested in power supply and distribution. It begins with an analysis of the increase in generating power in the United Kingdom, giving comparative data for several foreign countries, and with a discussion of the thermal efficiency of existing power stations. It proceeds to a detailed account of the design and construction of generating plant, and of the steps taken to improve thermal efficiency, and compares British and American developments. The survey covers all aspects thoroughly—steam conditions, turbine plant, boilers, materials, generators, transformers, switchgear, hydro-electric plant, buildings and civil works and future plans. A wealth of statistics is conveniently collected into tables throughout the paper.

OBITUARY

MAURICE GEORGE BLAND

Maurice George Bland, O.B.E., who died on the 7th September, 1955, was born on the 20th May, 1884. He received his general education at Wellingborough School and his technical training at London University. He gained practical experience in the London and Chesterfield works of Bryan Donkin and Clench, and subsequently with W. H. Allen, Son and Co., at Bedford. He joined his uncle's firm of Albion T. Snell and Partners, Consulting Engineers, in 1910, as a Junior Partner.

In 1914 he was granted a commission in the Royal Engineers (Searchlights) and in 1918 was Chief Engineer, London District, with the rank of Major. He remained with the Royal Engineers until 1920, when he was made an O.B.E. (Military Division), and returned to Albion T. Snell and Partners.

During his early military career he made successful representation for women to be enrolled into the services for clerical, catering and similar duties. From 1926 until 1931 he commanded the 26th Anti-Aircraft Battalion, Royal Engineers, Territorial Army, with the rank of Lieutenant-Colonel. During the Second World War he was an active member of the Home Guard.

In September, 1942, he went into practice as a consulting engineer on his own account and founded the firm of Maurice G. Bland and Son, which specialized, though not exclusively, in engineering services for hospitals and the exhibition buildings of Olympia.

Lt.-Col. Bland joined The Institution as a Student in 1904, and was elected an Associate Member in 1911 and a Member in 1952. L. S. A.

IVON BRABY

Ivon Braby, who died on the 21st December, 1955, was born on the 10th April, 1873. He was educated privately and at the Crystal Palace School of Engineering, where he later became a lecturer, and at the City and Guilds Central Technical College, South Kensington, where he took the full course in electrical engineering from 1893 to 1896, gaining the Diploma of the City and Guilds Institute in his final year.

In 1896 he was appointed Chief Electrician at the Fowler Waring Cables Co., where he was in charge of all cable tests and research work, and managed the company's factory at Woolwich. During his two years with that firm he supervised cable work at several towns in this country and also at Paris and Charleroi, Belgium. The following two years, 1898 to 1900, he spent at Siemens Bros. and Co., Woolwich, engaged on the design of dynamos, motors and electric traction schemes. He entered his father's firm of Frederick Braby and Co. in 1900 as a Consulting Engineer, and carried out work on electric-lighting and power-transmission schemes and commercial electrolytic processes. In the following year he became Managing Director and Chief Engineer in the firm of Braby and Tomlinson of Bloomsbury. He was appointed Assistant Secretary of Frederick Braby and Co. in 1903, a Director in 1911 and became Manager of the Deptford works of the company in 1912. His early experience was of great value in the installation of electricity, including separate motors for all the machines in place of the steam engine and line shafting previously used. He remained a Director of the family business until his retirement in 1945, and served as Deputy Chairman from 1935 until 1942.

He relinquished his post as Manager at Deptford in 1926 owing to ill-health—he was never very robust—and moved from London to Ross-on-Wye where his energies found a congenial outlet in participation in local activities. He was Honorary Treasurer of the Ross Parochial Church Council for some time until 1937, a representative of the council on the Diocesan Conference and a member of the Hereford Diocesan New Board of Finance, President of the Ross Ambulance Division of the St. John Ambulance Brigade, Secretary of the Ross and District Nursing Association and, throughout the 1939–45 War, Chairman of the Ross National Savings Committee.

He was the author of a book 'Whatever is—is Right', published in 1952, in which he examined the relationship between body, mind and spirit, the problem of suffering, and the object of human existence.

Ivon Braby was a man of deep religious convictions, in the light of which he conducted his public and private life; he was distinguished for his warm humanity and uprightness of character. He had a remarkable insight into all aspects of a problem, which he carefully analysed before reaching an opinion, and his advice was, in consequence, highly valued, being given with great clarity, but with the utmost consideration for the views of others. He was regarded by his staff as a model employer whose modesty was not the least of his charms. He is survived by his wife and three daughters.

Mr. Braby joined The Institution as an Associate in 1896, and was elected an Associate Member in 1899 and a Member in 1902. S. J. A.

ARTHUR STEPHENSON CARR

Arthur Stephenson Carr, M.A., who died on the 15th December, 1955, was born on the 25th July, 1889. He was educated at Chapeltown Elementary School and Leeds Modern School, and gained practical experience by means of a pupilage with Sheepscar Foundry, Leeds, and Robert Middleton, Leeds, from 1906 to 1907, during which time he studied general engineering at evening classes at Leeds School of Technology.

Moving to London in 1908, he worked with the Post Office as a Test Room Assistant, and later in the same year he was promoted to Acting Inspector. While in London he took evening courses at the Northampton Polytechnic (1908) and the Regent Street Polytechnic (1909–10). In 1912 he was promoted to the rank of Senior Inspector at the Post Office Engineering Department, Cambridge, where he was engaged on the maintenance and development of telephone lines and exchanges.

During the First World War, Mr. Carr served with the Divisional Engineers Royal Naval Division in Egypt and Gallipoli, and later with the Royal Artillery in France and Belgium.

Returning to the Post Office at the end of the war, he resumed his duties as an Inspector in the Cambridge area. He was able to attend a course at Cambridge University, and received a B.A. degree in 1922 in science and economics,

and later proceeded to M.A. His promotion was steady; in 1923 he was appointed a Chief Inspector at Southport, in 1928 an Assistant Engineer at Preston, in 1936 an Executive Engineer, supervising the maintenance and construction of all Post Office engineering plant in the Lancaster area, and eventually an Area Engineer. He was responsible for the conversion of many telephone exchanges from manual to automatic working.

Wherever he was Mr. Carr took a keen interest in local affairs, particularly those of a scientific or technical nature, and was always ready to help and advise young engineers. While at Lancaster he was a member of the Engineering Board of Lancaster Technical College, and a founder member of the Lancaster Engineering Society. He was also an active Rotarian. He is survived by his widow and two daughters.

Mr. Carr joined The Institution as a Student in 1913, was elected an Associate Member in 1916 and a Member in 1945.

G. J. S. L.

CHARLES VALENTINE JOHNSON

Charles Valentine Johnson, who died on the 21st November, 1955, was born on the 23rd February, 1892. He was educated by private tuition and received his practical training with W. G. Allen and Sons, constructional engineers of Tipton, Staffordshire, from 1908 to 1910. He then took up a post as Electrical Draughtsman with the Midland Electric Corporation for Power Distribution, Tipton, and stayed with that firm until 1919, being promoted to Substation Inspector in 1918. During this time, from 1912 to 1917, he attended part-time classes at the School of Arts and Sciences, Dudley, and the Birmingham and Midland Institute, Birmingham.

In 1919 he was appointed Mains Superintendent with the Leicestershire and Warwickshire Electric Power Co. at Hinckley, responsible for the control of the distribution system in Leicestershire and Warwickshire. While he was with this firm he passed The Institution's examination for Associate Membership, in 1923. He joined Rugby Corporation in 1935 as Deputy Borough Electrical Engineer, and in 1936 he went to Eccles Corporation as Borough Electrical Engineer. On the nationalization of the industry he was appointed Consumers' Engineer for the No. 1 Sub-Area of the North Western Electricity Board.

Mr. Johnson joined The Institution as an Associate Member in 1923 and was elected a Member in 1941. H. S. B.

JOHN ALOYSIUS KENNY

John Aloysius Kenny, who died on the 29th December, 1955, was born on the 4th January, 1888. He was educated at Blackrock College, Dublin, and received his early practical training with the Dublin United Tramway Co. from 1906 to 1911, being promoted to Station Engineer in 1908. He attended evening classes at the Pembroke and City of Dublin Technical Schools in these years to study general and electrical engineering.

He went to Scotland in 1911, and obtained an appointment as Electrical Engineer with the Paisley District Tramways and Lighting Co., and continued to further his studies by taking an evening course in general engineering from 1911 to 1913 at Glasgow Technical College. Late in 1918 he returned to Ireland to take up employment as Chief Assistant to Mr. J. P. Tierney, a Dublin consulting engineer, and a few months later Mr. Kenny became a principal of the firm. In his capacity as a consulting engineer he was responsible for the design, layout and completion of numerous urban supply schemes, and for the design of electrical installations in various public buildings, including the National Maternity Hospital, Dublin, one of the first all-electric hospitals in the world.

Mr. Kenny had many interests outside his profession. He was associated with the Catholic Social Service Conference and the Irish Red Cross Society, and was at one time President of the Blackrock College Union. Those who knew him will miss a good friend with a kindly, helpful and most courteous disposition.

He joined The Institution as an Associate Member in 1920 and was elected a Member in 1939. He served on the Irish Centre Committee from 1921 to 1924 and again in 1938–39. He was a Vice-Chairman of the Committee from 1939 to 1941 and Chairman from 1941 to 1943. He continued to serve on the Committee from 1945 to 1948. J. D. F.

FREDERICK WALTER PURSE

Frederick Walter Purse, who died on the 24th November, 1955, was born on the 5th February, 1879. He received both his general education and his training in electrical engineering at the University of Bristol from 1890 to 1897, and subsequently studied general engineering at evening classes at the same centre. He obtained practical experience under Mr. H. Faraday Proctor at the Electricity Department of Bristol Corporation, from 1897 to 1899, and during that time he gained the Diploma of the City and Guilds Institute, with Honours.

For two years, till 1901, he held the position of Engineer-in-Charge at the Electricity Department, Bath, and he then obtained an appointment as Chief Assistant to the Electrical and Tramways Engineer at Warrington, staying in this post for seven years. In 1908 he was appointed Chief Electrical Engineer at the Electricity Department, Watford, where he was responsible to the Council for all work of the department, including the carrying out of all extensions. In a similar capacity he moved to Carlisle in 1913, to West Ham in 1919, and eventually to the London and Home Counties Joint Electricity Authority in 1929. He continued in this post until 1946.

To Mr. Purse, electricity supply was not only a career but an all-absorbing enthusiasm. His other interests—apart from the domestic background from which he derived so much happiness—were few. But wherever in the service of electricity supply his considerable talents were in need, there they were always generously available.

Mr. Purse's contributions to the development of the electricity supply industry extended well beyond his official appointments. His insistence upon the highest possible standards is recalled by his association with the National Register of Electrical Installation Contractors. He served on many and various committees, being President of the Incorporated Municipal Electrical Association in 1927–28, President of the Building Industries National Council from 1946 to 1948, Chairman of the Electrical Development Association in 1940–41 and President of the West Ham Rotary Club in 1927–28. His contributions were invariably treated with respect, although at times they were the subject of controversy.

Those of us privileged to work with him recall pre-eminently a patent integrity which imparted a dynamic sense of purpose to all he did. He was in some ways a hard task-master—hardest when driving himself to some fresh effort.

He demanded much; he gave most. His ideas found expression in positive terms, plainly spoken. Yet he combined with an almost austere refusal to compromise, a personal charm of persuasiveness which often secured the acceptance of his ideas notwithstanding the occasional first shock of their impact.

Mr. Purse joined The Institution as a Student in 1898, and was elected an Associate in 1901, an Associate Member in 1904 and a Member in 1912. He served as a Member of Council from 1928 to 1931, and as a Vice-President from 1931 to 1934. He was a member of the Transmission Section Committee from 1937 to 1939 and Chairman in 1939–40. He was also a Member of The Institution of Mechanical Engineers.

CECIL STRAFFORD

Cecil Strafford, who died on the 15th September, 1955, was born on the 28th August, 1876. He received his electrical engineering education at Melbourne Technical College from 1892 to 1894, and his practical training with the Australian Electric Co. from 1894 to 1897. For the next three years he worked with various electrical companies in Australia, and then, in 1901, joined the P. and O. Steam Navigation Co., staying with them for seven years. In 1908 he obtained an appointment as Chief Electrical Engineer with the Taikoo Dockyard and Engineering Co. at Hong Kong, in which position he was responsible for the entire electrical equipment of the company, including the generating station, and supervised all electrical work carried out.

In 1921 he accepted the post of Resident Engineer with the China Light and Power Co., also at Hong Kong, and was responsible for the working of the power station. In 1924 he was promoted to work in an executive capacity as Assistant Manager, and rose to the position of Manager within six years.

Owing to the ill health of his wife he retired in 1933, but undertook the work of looking after the company's interests in the United Kingdom. He continued in this post until his final retirement in 1954. He is survived by his widow.

Mr. Strafford joined The Institution as an Associate Member in 1903 and was elected a Member in 1933.

D. W. M.

WILLIAM GILBERT TURNER

William Gilbert Turner, who died on the 17th October, 1955, was born on the 19th January, 1884. He was educated at the Perse School, Cambridge, and obtained his engineering training from C. A. Parsons and Co., Newcastle upon Tyne. While at Newcastle he studied general and electrical engineering at Rutherford College, Durham College of Science and Armstrong College. After five years he joined the staff of the then Newcastle and District Electric Lighting Co., where he became Chief Assistant Engineer in 1908.

He was appointed Borough Electrical Engineer to Southampton Corporation in 1920, and, on the nationalization of the electricity supply industry in 1948, took up his duties as Manager of the Portsmouth Sub-Area, Southern Electricity Board, until his retirement in 1950.

Upon his appointment at Southampton Mr. Turner applied himself to the task of modernizing and developing the generating station and by the end of 1922 he had put into operation three-phase a.c. generation at a voltage of 6·6 kV. The distribution system was correspondingly modernized to meet the requirements of a growing seaport and increasing power demands, the voltage being stepped up to 11 kV for extensions beyond the borough boundary and ultimately to 33 kV for an underground ring main encircling the principal parts of the area.

The generating station became a 'selected' station under the Electricity (Supply) Act, 1926. Mr. Turner was a member of the first established Consultative Technical Committee for the South-West of England and South Wales Area of the Central Electricity Board, in 1932.

On the occasion of its jubilee, Mr. Turner wrote an excellent history of the Southampton undertaking, following this later by an interesting and important brochure on the undertaking's war history.

He held his appointment as Manager of the Portsmouth Sub-Area during the difficult period of reorganization following nationalization. This involved the amalgamation and reorganization into five districts of four private companies and five local-authority undertakings, previously responsible for the supply of electricity in this area of approximately 1 200 square miles.

Mr. Turner will be remembered for his exemplary management, his integrity, his great capacity for work, his quiet insistence on accuracy in all things, and his love for recording in detail the development of the electrical industry to which he was so devoted. He was keenly interested in archaeology and was a member of the Hampshire Field Club. At one time he was also honorary treasurer of the Southampton Records Society.

He joined The Institution as a Student in 1904, and was elected an Associate Member in 1909 and a Member in 1929. He was Vice-Chairman of the Hampshire Sub-Centre in 1929–30 and Chairman in 1930–31, and continued to serve on the Committee from 1931 to 1933. He was also a member of The Institutions of Civil and of Mechanical Engineers.

H. T. E.

HUBERT WOOD

Hubert Wood, B.A., who died on the 9th October, 1955, was born on the 4th December, 1914. He received his early education at Bradford Grammar School and then proceeded to study at Corpus Christi College, Oxford, where he graduated with first-class honours in physics in 1936.

On leaving university, Mr. Wood joined the research staff of Ferranti Ltd. in their radio and television laboratory at Moston, Manchester, where he specialized in the development of television receivers. With the outbreak of war he was entrusted with senior responsibility in the development of radar equipment, where he made extensive contributions to the design of I.F.F. responders. When the war reached its conclusion, and civilian production was resumed, Mr. Wood assumed complete responsibility for the technical development of the company's post-war range of television receivers. He was appointed Manager of the Radio Department in February, 1952.

Mr. Wood had the forthright manner of a true Yorkshireman, and was gifted with a rare spirit of human understanding, which made him widely beloved, particularly amongst those who worked under him. He leaves a widow and three children.

He joined The Institution as an Associate Member in 1942 and was elected a Member in 1949. He served on the Committee of the North-Western Radio Group from 1946 to 1949.

R. G. B. G.

MONOGRAPHS AND PAPERS
published individually this month

Monograph, Individual Paper and Reprint Service

Synopses of monographs and papers published individually before the next issue of the Journal are given below, and, unless otherwise stated, their dates of publication are this month. Reprints of all papers are available about two months after publication in the Proceedings. The prices shown below are post free. When ordering please quote serial number of paper or monograph. Books of 8 vouchers may be obtained from the Secretary, price 10s. each.

There are special arrangements for the papers to be read at the Convention on Electrical Equipment of Aircraft. See the announcement on page 258.

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MONOGRAPHS

Resultant Reactive Power of Overhead Lines

MONOGRAPH No. 172 S

A. F. COVENTRY, B.Sc.

A method is demonstrated for arriving at simple formulae by which the resultant reactive power of overhead lines under any load condition can be quickly calculated, and in which the only line constant necessary to be known is the inductance. Tables of practical overhead-line inductances are given. The method is extended to lines containing series capacitors and also to low-voltage lines. The accuracy of the method, applied both to electrically short and long lines, is discussed fully in the appendix.

Reluctance of the Teeth of a Slotted Armature

MONOGRAPH No. 173 S

S. NEVILLE, B.Sc.(Eng.)

The paper treats of a practical method for calculating the m.m.f. required for a tapered tooth, which is correct over the whole range of flux densities and for all proportions of teeth, slots or ducts. Working curves are given for a typical core steel.

The Use of the Blackburn A.C. Network Analyser in the Analysis of Power System Faults

MONOGRAPH No. 174 S

J. H. BANKS, M.Sc., and K. C. PARTON, B.Sc.

The monograph describes the use of the Blackburn a.c. network analyser in analytical and analogue methods of investigating faults on 3-phase power systems. In the analytical approach, after defining the faults in matrix form by symmetrical components, the ensuing equations are solved by using the Blackburn analyser without the need for further matrix manipulation.

In the analogue method, it is shown how the constraints imposed upon the phase voltages and currents can be applied direct to the sequence networks by the connection of symmetrical-component operational matrices at the fault positions. No knowledge of the relationships between the symmetrical-component currents is required.

The 'equivalent series' connections of the sequence networks derived recently by Kirschbaum in America for application to the conventional network analyser are shown to be unnecessary when using the Blackburn machine.

H.F. Bearing Variations on an Adcock Direction-Finder

MONOGRAPH No. 175 R

E. N. BRAMLEY, M.Sc., Ph.D.

Measurements on a number of transmitters at ranges from 1000 to 5000 km show that the variance of snap bearings within a period of half an hour is of the order of 10 deg^2. To reduce this variance by a factor of ten, time averaging over about 5 min is required when the bearings are taken at 10 sec intervals. Bearing changes from hour to hour and from day to day have a variance of about 1 deg^2 and thus set a limit to the error reduction obtainable by averaging over a half-hour period. The results are consistent with previously published estimates of bearing variances.

PAPERS

Mine Locomotives

PAPER No. 2106 U; PART A

T. E. GREEN

The paper will be published on May 5th.

The paper reviews the conditions and restrictions governing the use of locomotives in British coal-mines, and the designs which have been evolved to meet them. The various types of locomotives are briefly described and some of the principal factors which determine the design of the locomotive are discussed. The Diesel engine, electrical equipment and power transmission gear are considered, and particular attention is paid to braking problems and couplings.

Operational experience, with a brief account of some important difficulties and the method of their solution, is included. An attempt is made to summarize the present position, indicate the immediate problems which must be solved and suggest further long-term lines of progress.

SOME RECENT BOOKS

W. N. LOCKE and A. D. BOOTH (*Editors*)
MACHINE TRANSLATION OF LANGUAGES

NEW YORK: TECHNOLOGY PRESS OF MASSACHUSETTS INSTITUTE OF TECHNOLOGY AND JOHN WILEY.
LONDON: CHAPMAN AND HALL. 255 PP. £2 8S.

Scepticism will give way to conviction, and conviction may even turn to enthusiasm on reading this work. The editors, who are respectively Head of the Department of Modern Languages of the Massachusetts Institute of Technology, and Director of the Birkbeck College Computation Laboratory in the University of London, have assembled here a collection of essays by themselves and fifteen other expert linguists and applied mathematicians. The essays cover the linguistic, semantic, logical and, to a lesser extent, the mechanical aspects of machine translation of languages. Initial discussions on the feasibility of this took place as far back as 1946 and the solid progress since achieved in Britain must surely be due largely to the energy of Dr. Booth. The essays themselves were written during the period 1949–54 and this spread of time has led almost inevitably to some incoherence, overlapping and unevenness in their presentation. Additional impetus was given to the investigations by the ever increasing bulk of technical and scientific literature published in less widely understood languages, notably Russian. Pilot experiments were therefore concentrated on this language, which despite the obvious difficulty of the unfamiliar Cyrillic alphabet, follows in its sentence construction—particularly in scientific writings—a pattern surprisingly close to that of English. The optimism which pervades the book is well illustrated by the following quotation from the contributor Warren Weaver: 'When I look at an article in Russian, I say "This is really written in English but it has been coded in some strange symbols. I will now proceed to decode it".' Mechanical translation does in fact achieve such a decoding. It depends in essence upon the availability of a large central storage element to replace the dictionary and grammar of the human linguist. The storage by some mechanical means of sets of technical terms having a one-to-one correspondence with one another in two languages may fairly readily be conceived, but the coding and subsequent recognition in an output language of a complicated accidence or system of inflections such as occur in Russian are an altogether different proposition. Other problems, syntactic or idiomatic, which have to be solved are legion. How for example, should the mechanical device be taught to render the Russian double negative into English, not as an affirmative as might first be thought, but as a negative; again, what should it do with the purely euphonic 't' of the French *y-a-t-il*? How must the peculiar incapsulated sentences of German and their imitations in the Scandinavian language be tackled? And if a 'red herring' be introduced into the English end of the machine, what will the German reader, ignorant of English, make of the *roter Hering* which emerges from the other?

It still remains debatable whether there is a need for pre-editing and post-editing the material supplied to the mechanical translator, but the samples in the book of translations from the Russian with no post-editing of the English would appear quite intelligible to a reader with specialist knowledge of the subject-matter.

Professional translators may fear that the advent of the machine translator will spell their ruin. This is unlikely, since the services of experienced linguists will always be required in programming the machines to perform specific tasks, while the prospect of the machines producing faithful and at the same time aesthetically satisfying translations of belletristic, as opposed to technical, material remains very remote.

M. WIND and H. RAPAPORT (*Editors*)
HANDBOOK OF MICROWAVE MEASUREMENTS

NEW YORK: POLYTECHNIC INSTITUTE OF BROOKLYN.
VOL. I, 595 PP. VOL. II, 341 PP. £4 4S. APPROX.

Twenty-five staff members of the Brooklyn Microwave Research Institute are the contributing authors of this handbook, which was commissioned by the United States Army Signal Corps. Microwave engineering has now some fifteen years of adult stature and its measuring techniques are stabilizing a little. At least, methods of measuring the more fundamental parameters of pulse-type transmission systems are becoming fairly standard. There is a real need for these methods to become widely known by development engineers and their assistants, and this book will help appreciably.

The main aim of the book is to present to both engineers and technicians an ordered, critical collection of the measurement techniques that have found favour so far. It has an introduction, twenty main sections, each devoted to a particular topic, and four appendices. Each main section opens with a review of the problem and with outlines of the methods of measurement to be dealt with. Then follows a detailed account of each method, a description of the equipment assembly, and a detailed step-by-step indication of the measurement procedure, often followed by a numerical example as illustration of typical results to be expected. Finally, notes are given on the accuracy of the method and the precautions that must be taken to obtain reliable results. The first ten sections are concerned with the more fundamental measurements of the transmission characteristics such as power, impedance. attenuation, standing-wave ratio, etc., while the second half of the book deals with the performance of particular transmission elements and microwave components. Klystrons, magnetrons, T–R tubes and crystals each have a chapter. One section gives useful information on the measurement of receiver characteristics; not only does the r.f. stage receive attention but the i.f. and video stages are given a few pages. This is all to the good as it serves to emphasize to the microwave engineer that a complete receiver is often a major part of his equipment and that he must be able to ensure that it is performing sensibly.

The project has been carried out very thoroughly indeed and the book certainly succeeds in presenting a large collection of microwave-measurement methods for reference purposes. On the whole it assumes that the test components and equipment are freely available to the engineer and the reader must not expect to find working drawings enabling him to go into immediate production of any measurement section which he happens to lack.

Very little help is given to the communication engineer on microwave filters, phase responses, cross-modulation problems, travelling-wave tubes, etc., probably because the two volumes

together already weigh 5¼ lb and because the communication-system designer has not yet solved his measurement problems completely.

The book has been lithographed from the typewritten draft and has paper covers. Apparently the Signal Corps is responsible for a style of production resulting in a book that is clumsy, heavy to handle and yet expensive. Although a separate volume (II) of illustrations allows them to be viewed simultaneously with the associated text, the manual effort required to keep Volume I open and the page flat enough to read produces a state of physical exhaustion even before mental fatigue sets in. A good six square feet of table space is advisable.

Any microwave laboratory would be well advised to acquire a copy of the book for reference purposes as it would be particularly useful to those engineers who possess only a moderate experience of the subject.

A. J. YOUNG

AN INTRODUCTION TO PROCESS CONTROL SYSTEM DESIGN

LONGMANS. 395 PP. £2 2S.

As its name implies, this book is intended to introduce chemical engineers and others to the subject of process control and does not attempt to be a control engineers' manual. This has resulted in a book which contains almost no mathematics, but is a highly practical and easily readable exposition not only of the basic principles of chemical plant control but also of the available instruments and controllers. Mr. Young probably brought to his task a wider experience of process control than any one else in this country, and it is well known that his team in I.C.I. has been the mainspring of British development in process control.

After a very short introduction, Mr. Young goes on to discuss the economics of process control. This is probably the right beginning, for what control equipment is fitted to any chemical plant must depend on them. The sooner control engineers appreciate this the more their wares will be in demand, and if the young control engineer never gets beyond these first seventeen pages but takes them to heart, his two guineas will have been well spent.

Then follows a very short chapter to distinguish between open- and closed-loop systems. It is a pity that here the author has not tried to bring the process-control schematics and nomenclature into line with that customary for position control. In this he is, of course, tied by the B.S.I. recommendations, which he has followed throughout his book. Unfortunately, although position-control and process-control engineers are at last nearing agreement and more are becoming concerned with both types of control, in the nomenclature the dichotomy still persists. In the reviewer's opinion there are very good technical reasons for adopting in process control the nomenclature and symbolism well known to position-control engineers.

Mr. Young then discusses plant characteristics and control and the methods developed by his team for plant analysis. The determination of the dynamic characteristics of plant is the real problem in process control and these chapters are most worth while. Then come descriptions of existing controllers and their application, which cover a wide range of controls; this section will be valuable for reference during the next few years.

The author next returns to plant behaviour, pointing the way to the proper integration of the control system with the plant, which so far has never been attempted and which Mr. Young knows full well will be essential in the future. The development of more economical chemical processes in general depends on smaller plants with greater throughput, which in turn may mean higher working pressures and temperatures that have to be controlled very much more accurately. Under these conditions unwanted fluctuations, such as Mr. Young discusses in Chapter 17, become more and more important; this is well known in position control and much work has been done on the design of the best systems to meet such conditions. In linear systems, the problem is virtually solved and attention is now being given to non-linear systems. Already approximate methods have been developed which enable some non-linear systems to be optimized. There is no basic difference between process and position control—only a difference of degree mainly because the process-control engineer has not been concerned with unwanted fluctuations in high-performance systems, as has the position-control engineer. The new requirements of the chemical industry are approaching those which have to be met in high-performance position controls and there is little doubt that the problems can only be solved similarly.

HERBERT F. STORM and others

MAGNETIC AMPLIFIERS

NEW YORK: JOHN WILEY. LONDON: CHAPMAN AND HALL. 564 PP. £5 8S.

This book by Dr. Storm and some colleagues might properly be described as the first authoritative work on magnetic amplifiers. The first three chapters give an account of ferromagnetism, magnetic materials and magnetic testing. Chapters 4–20 are by Dr. Storm himself, and these contain some 250 pages dealing with the transductor and its basic theory. Series and parallel transductors without feedback are first considered for high- and low-impedance windings, and the transient response is both explained physically and presented in the form of a linear transfer function. A full account is also given of the steady-state and transient operation with inductive loading, but little is said about capacitive loads. High-gain circuits using feedback and amplistats (auto-excited transductors) are fully discussed and an admirable treatment of the effect of rectifier imperfections is given. The effects of core permeability, iron losses, etc., are perhaps somewhat neglected. Various types of core and coil assemblies are considered in Chapter 21, while the remaining chapters deal primarily with applications. These cover a wide range including voltage and frequency controls, servo amplifiers, instrument amplifiers, rectifier controls and many others.

The contributors to this work are amongst the most highly regarded authorities in the United States; this is considerable compensation for a slight lack of integration, which is perhaps inevitable when there is more than one author. The main criticism of this book arises from a number of vital omissions. Transductors (saturable reactors) are treated with infinite thoroughness. The title 'Magnetic Amplifiers' however justifies one in expecting a wider coverage. For example, little mention is made of high-speed circuits or low-level amplifiers, and the treatment of the all-important push-pull amplifiers is disappointingly sparse. Finally the theories given are not adequately correlated with every-day design problems.

In conclusion, this book is a very valuable reference for the research worker, but the practising electrical engineer will find the theoretical sections somewhat specialized.

**Denotes that the publication is also in the Lending Library. The publications cannot be bought through The Institution; the publishers and the prices are given only for the convenience of members.*

LIBRARY ACCESSIONS

BOOKS

ANDERSON, G. F. 93:621.311

Fifty Years of Electricity Supply. The story of Sydney's Electricity Undertaking

Sydney, Sydney County Council, 1955. pp. 257. 23 × 14 cm.

AYER, A. J., and OTHERS 621.392

Studies in Communication. Contributed to the Communication Research Centre, University College, London*

London, Secker and Warburg, 1955. pp. vii, 182. 22 × 15 cm. 21s.

Nine lectures delivered to invited audiences during the first year of the centre. The authors and the titles indicate the wide range of subjects involved in human communication, the interests aroused, and the co-operation which exists.

BRAME, J. S. S., and KING, J. G. 662.6

Fuel. Solid, liquid and gaseous*

5th ed. London, Arnold, 1955. pp. xii, 551. 24 × 16 cm. £2 10s.

Gives a brief review of world resources. Discusses the essential properties of fuels, including pulverized coal, and oil produced from coal, and the important aspect of combustion methods. Domestic and other uses are considered besides the requirements of boiler houses.

CARR, T. H. 621.311.17

Electric Power Stations, Vol. 2*

4th ed. London, Chapman and Hall, 1955. pp. xvi, 832. 22 × 14 cm. £4.

The latest edition of this well-known work represents no great change over the third edition. Revision where necessary has been made and some new material has been added.

CARR, T. H. 621.315

Mains Practice. Transmission and distribution of electrical energy*

London, Newnes, 1956. pp. vii, 352. 23 × 15 cm. 35s.

A concise review of the systems and methods of transmission and distribution. It indicates not only the advantages and disadvantages from the technical point of view, but also economic considerations.

DANIELS, F., and DUFFIE, J. A. (Editors) 620.9

Solar Energy Research*

London, Thames and Hudson, 1955. pp. xv, 290. 24 × 16 cm. 30s.

The growth of world population and the consumption of expendable fuels give a sense of urgency to research into the possibilities of utilizing solar energy. Local weather conditions must be studied in considering any scheme. The simplest application is possibly solar home heating, involving problems of architectural design and heat storage, and the usefulness of the heat pump is pointed out. The conversion of radiation to mechanical power and for the distillation of sea-water to supply water for drinking and irrigation is discussed. Schemes for converting solar energy directly into electricity, using photovoltaic cells, etc., are also referred to. This book was reviewed in the March Journal.

DOSSE, J. 621.314.7

Der Transistor. Ein neues verstärkerelement (A new amplifier component)*

Berlin, Siemens and Halske, 1955. pp. 109. 21 × 16 cm.

Based on a series of lectures given in 1954 it surveys the historical development, explains the mode of operation and describes the different types of transistor giving their properties. Circuits and application are indicated and there is a useful bibliography.

ENGEL, A. VON 537.56

Ionized Gases*

Oxford, Clarendon Press; London, Cumberlege, 1955. pp. x, 281. 24 × 16 cm. £2 2s.

Gives a concise but comprehensive treatment of fundamental processes, and so deals less extensively with the details of the theories, and their more practical use. Includes a considerable amount of data, a detailed index, and an extensive list of bibliographical references.

FRANCIS, W. 662.6

Boiler House and Power Station Chemistry*

3rd ed. London, Arnold, 1955. pp. xii, 348. 22 × 15 cm. £2 10s.

The first part of this book gives an explanation of the chemical properties and processes involved. It deals with solid and liquid fuels and their combustion, with the treatment of boilers, flue gases, and boiler feed waters. Discusses the efficient combustion of fuels, the utilization of waste heat, and other considerations relating to the efficient conversion of heat into electricity. The second part of the book is for the chemist and deals with the analysis, etc., of fuels.

GLASFORD, G. M. 621.397

Fundamentals of Television Engineering*

New York, McGraw-Hill, 1955. pp. xiv, 642. £3 11s. 6d.

Deals first with fundamental principles, then with the necessity for standardization of scanning, synchronizing and so on, and with the reason for a particular choice of standards and methods. The several parts of a transmitter–receiver system are analysed and discussed in detail, the special problems of colour television being integrated into the general treatment.

GLASSTONE, S., and EDLUND, M. C. 621.039

The Elements of Nuclear Reactor Theory

London, Macmillan, 1955. pp. vii, 416. 24 × 16 cm. 35s.

Introductory chapters explain the physical processes occurring in a nuclear chain reactor. The main body of the book deals with the fundamental principles involved in calculating the critical conditions for thermal-neutron chain-reacting systems. This book will be reviewed in a future issue.

GOLDING, E. W. 621.311.24

The Generation of Electricity by Wind Power*

London, Spon, 1955. pp. xvi, 318. 22 × 14 cm. £2 10s.

An account of recent research and development work in this country and abroad. Deals with wind behaviour and its determination and the selection of sites, with wind-driven machines and with economic considerations. Selected bibliographies are given at the end of each chapter. This book will be reviewed in a future issue.

HASTINGS, C. 518.5

Approximations for Digital Computers

Princeton, New Jersey, Princeton University Press, 1955. pp. viii, 201. 32s.

Introduces a collection of approximations, for which error curves are provided, using a method that combines judgment and intuition with formal mathematics.

HURCOMB, The Rt. Hon. Lord 621.311.21

Hydro-Electricity and Nature Protection. Stating the case

Brussels, International Union for the Protection of Nature, 1955. pp. 224. 24 × 16 cm.

The number of subjects discussed at the meeting in 1952 made it impossible, in the three-language report of 550 pages (published in 1954), to do justice to the important contribution on hydro-electricity. The present volume has therefore been prepared to ensure that abstracts at least of the more important papers are made available. The papers have been arranged to give a balanced appraisal of the varying points of view concerning the effects of interfering with natural conditions for hydro-electric developments.

JAMES, B. 534.85

Hi-Fi for Pleasure. A guide to equipment*

London, Phoenix House, 1955. pp. 134. 18 × 12 cm. 9s. 6d.

This easily readable and entertaining little book, intended for the non-technical reader, gives a very real explanation of the problems involved in obtaining high-fidelity reproduction. The author is not so much concerned with the problems of recording—taken care of by the recording engineers—but with the proper use of good modern reproducing equipment such as pick-ups, amplifiers and loudspeakers, and, in particular, with the adjustment of the controls to suit domestic listening conditions.

Convention on Electrical Equipment of Aircraft

The programme for the Convention on Electrical Equipment of Aircraft (2nd–4th May, 1956) appears below. Programmes and registration forms for the Convention are being sent to all those who have applied for them. Included in the programme are details of all papers to be presented at the Convention. The individual publication of a few has already been announced in the *Journal*, and it is hoped that the remaining papers will be published shortly before the Convention. The papers are available to all participants in the Convention on payment of a nominal fee. The papers will be republished later, together with reports of the discussions, in a supplement to Part A of the *Proceedings*. Application for sets of papers and for the supplement to Part A should be made on the registration form.

Wednesday, 2nd May

SESSION 1. OPENING SESSION

5.30 p.m. (tea at 5 p.m.)

Chairman: **Sir George H. Nelson, Bart.**, President

Opening Speaker: **The Rt. Hon. Reginald Maudling, M.P.**, Minister of Supply

Introductory Talk: **G. R. Edwards, C.B.E.**

followed by

'Electrical Equipment in Aircraft: Survey of Past and Present Practice and Future Trends in Design' (Paper No. 2062 U)	**S. F. Follett, B.Sc.(Eng.)**

Thursday, 3rd May

SESSION 2. ELECTRICITY IN AIRCRAFT

10 a.m.

'Factors in the Utilization of Electrical Power in Aircraft' (Paper No. 2067 U)	**H. Zeffert**
'Aircraft Radio Power Supplies: A Survey' (Paper No. 2105 U)	**B. J. O'Kane, Ph.D., B.Eng.**
'The Airworthiness and Reliability of Aircraft Electrical Systems' (Paper No. 2081 U)	**J. F. Lewis, B.Sc.(Eng.), and E. Lloyd, B.Sc.(Eng.)**

SESSION 3. AIRCRAFT ELECTRICAL SYSTEMS

2.30 p.m.

Rapporteur: **M. Hancock**

'The Medium-Voltage D.C. System in Aircraft and its Application in the "Princess" Class Flying Boats' (Paper No. 2057 U)	**A. Ball, B.E.M., and R. N. Lake, B.Sc.(Eng.)**
'Rectified-A.C. Generating Systems in Aircraft' (Paper No. 2071 U)	**P. L. Cronbach, B.Sc.(Eng.)**
'A Constant-Frequency A.C. System for Aircraft' (Paper No. 2045 U)	**P. C. Finucane**
'Future Trends in Aircraft Electrical Systems' (Paper No. 2091 U)	**D. C. Flack, B.Sc.(Eng.), Ph.D.**

SESSION 4. MACHINE EQUIPMENT

5.30 p.m. (tea at 5 p.m.)

'Trends in the Development of Airborne Electrical Equipment, with particular reference to Constant-Frequency A.C. Systems' (Paper No. 2089 U)	**R. H. Woodall, P. J. Daglish, B.Sc., and V. A. Higgs, B.Sc.**
'Electrical Machines for Aircraft' (Paper No. 1971 U)	**B. Adkins, M.A., W. Philipp, B.Sc., and A. Hossle, B.Sc. (Eng.)**
'The Cooling of Aircraft Electrical Equipment' (Paper No. 2056 U)	**C. S. Hudson, B.Sc., Ph.D., Wh.Sc.**

Friday, 4th May

SESSION 5. SYSTEM EQUIPMENT

10 a.m.

Rapporteur: **S. F. Follett, B.Sc.(Eng.)**

'Electrical Characteristics and Protection of Aircraft Power Systems' (Paper No. 2088 U)	**K. J. Payne, B.Sc.**
'Aircraft Switchgear' (Paper No. 2087 U)	**W. G. Bourne and A. Grieve, B.Sc.**
'Aircraft Electrical Cables' (Paper No. 1994 U)	**D. W. Bird, B.Sc., D. C. Hancock, B.Sc., Ph.D., F.R.I.C., and D. B. McKenzie, B.Sc.**
'The Development of Voltage and Frequency Regulators for Aircraft Electrical Systems' (Paper No. 2054 U)	**C. W. Cooper, B.Sc.(Eng.)**
'Aircraft Batteries and their Behaviour on Constant Potential Charge' (Paper No. 2110 U)	**G. A. Earwicker**
'D.C. Circuit Interruption and Arc Characteristics at Low Air Pressures' (Paper No. 1935 U)	**A. H. M. Arnold, D.Eng., Ph.D., and L. H. Ford, M.Sc.(Eng.)**
'The Current and Voltage Relationships of a Stable D.C. Arc between Copper and Silver Electrodes in Air at 1–760 mm Hg' (Paper No. 2042 U)	**I. A. Mossop, B.Sc.Tech., and F. D. Gill, B.Sc.(Eng.)**

SESSION 6. INSTALLATION AND MAINTENANCE

2.30 p.m.

Discussion opened by A. J. Cope, C. C. Jackson and R. D. Jones.

ANNOUNCEMENTS TO MEMBERS

THE HOMES FUND

SUMMARY OF CONTRIBUTIONS RECEIVED TO 25TH MARCH, 1956

	No. of Contributors	£	s.	d.
£1 000 and over	6	6 000	0	0
£100 to <£1 000	29	6 386	3	0
£5 to <£100	782	8 522	16	5
£2 to <£5	1 902	5 249	7	2
Under £2	19 350	10 176	19	11
		£36 335	6	6

ANNUAL GENERAL MEETING OF THE INSTITUTION

THURSDAY, 17TH MAY, 1956, AT 5.30 P.M.

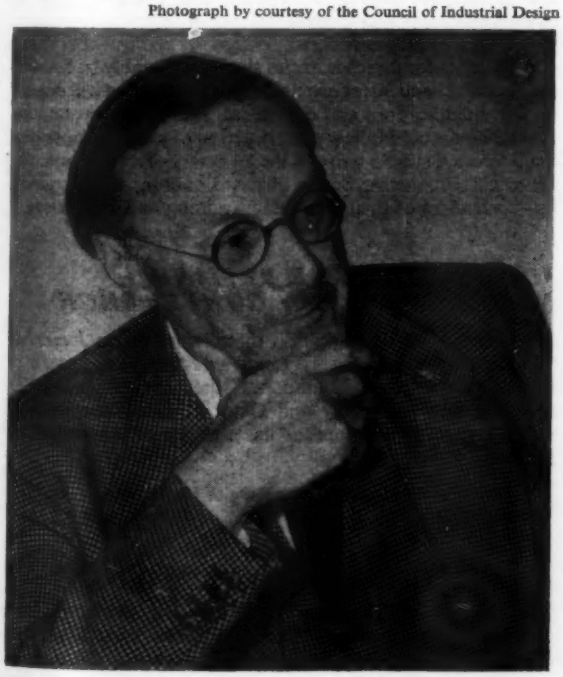
Notice is hereby given that the **Annual General Meeting** of The Institution of Electrical Engineers will be held on Thursday, 17th May, 1956, at 5.30 p.m., at the Institution Building, Savoy Place, London, W.C.2, to receive and consider the Accounts for the year ended 31st December, 1955, and the Annual Report of the Council, and to elect Auditors.

Copies of the Accounts and Report (which will in due course be published in the *Journal*) can be obtained on application to the Secretary about ten days before the date of the meeting.

By order of the Council,
W. K. BRASHER,
Secretary.

Sir Gordon Russell

Photograph by courtesy of the Council of Industrial Design



LECTURE BY SIR GORDON RUSSELL

Members are reminded that the Annual General Meeting on the 17th May will be followed at 6.30 p.m. by a lecture on *Appearance Design* by Sir Gordon Russell, C.B.E., M.C. This famous designer of modern furniture, who has written, lectured and broadcast on the subject for many years, is the Director of the Council of Industrial Design. He has travelled widely in Europe and America and is in touch with the best-known designers in many countries.

THE GRAHAM CLARK LECTURE

27TH APRIL, 1956

The Graham Clark Lecture will be delivered this year by Sir Maurice Bowra, F.B.A., M.A., D.LITT., who will speak on *The Impact of Engineering on Society*. Sir Maurice, who is Warden of Wadham College, Oxford, is a distinguished scholar of classical literature. He has travelled widely, and written extensively on Greek literature, besides interesting himself in modern languages and the comparative study of various literary forms and movements. From 1946 to 1951 he was Professor of Poetry at Oxford and subsequently Vice-Chancellor of the University.

His lecture will be concerned with the fundamental aims of engineering and the part it has played in various civilizations throughout history. He will consider the influence of engineering on the material welfare of society, and will examine the arguments advanced against engineering through its possibly bad effects upon man's intellectual development.

The lecture will be held on Friday, 27th April, 1956, at 5.30 p.m., in the Lecture Hall of The Institution of Mechanical Engineers. No tickets of admission are required.

Sir Maurice Bowra

APPOINTMENTS AND NOMINATIONS

BRITISH STANDARDS INSTITUTION ENGINEERING DIVISIONAL COUNCIL

The Council have nominated Mr. P. Dunsheath, C.B.E., M.A., D.SC.(ENG.), PAST-PRESIDENT, to serve on the above Council in place of Mr. T. G. N. Haldane, M.A., PAST-PRESIDENT.

Sub-Committee on Interchangeable Crane Components (MEE/41/11)

The Council have nominated Mr. C. G. Oram, MEMBER, to serve as their representative on the above Committee.

CODES OF PRACTICE COUNCIL

Codes of Practice Committee for Electrical Engineering (ELCP/–)

The Council have nominated Mr. R. A. Marryat, B.SC.(ENG.), MEMBER, to serve as their representative on the above Committee in place of Mr. H. J. Cash, MEMBER.

Code Drafting Committee on Electrical Installations—General (ELCP/2)

The Council have nominated Mr. Forbes Jackson, M.I.MECH.E., MEMBER, to serve as their representative on the above Committee in place of Mr. H. J. Cash, MEMBER.

Code Drafting Committee on Wiring Systems (ELCP/10)

The Council have nominated Mr. R. A. Marryat, B.SC.(ENG.), MEMBER, to serve as their representative on the above Committee in place of Mr. H. J. Cash, MEMBER.

Code Drafting Committee on Earthing (ELCP/17)

The Council have nominated Mr. R. A. Marryat, B.SC.(ENG.), MEMBER, to serve as their representative on the above Committee in place of Mr. H. J. Cash, MEMBER.

Codes of Practice Committee for Mechanical Engineering (MECP/–): Code Drafting Committee on Guarding of Machinery

The Council have nominated Mr. F. H. Mann, MEMBER, to serve as their representative on the above Code Drafting Committee and on the associated Steering Committee.

SUPPLY SECTION

The Annual Lecture of the Supply Section will be held on the 16th May, 1956, when Dr. R. L. Hearn, B.A.SC., D.ENG., Chairman of the Hydro-Electric Power Commission of Ontario, will speak about a major Canadian hydro-electric development, namely 'The Sir Adam Beck Generating Station No. 2 at Niagara'. The Supply Section Committee believe that this Lecture will prove of great interest to members and a large attendance is expected.

ADVERTISEMENTS IN THE *JOURNAL* AND *PROCEEDINGS*

Owing to the increases in the price of paper, printing and binding the cost of producing the *Journal* and *Proceedings* is mounting inexorably. The Council therefore consider it necessary to do all they rightfully can to increase the quantity of advertising in both periodicals; a greater number of advertisement pages would be of real help in offsetting some of the drain on The Institution's funds caused by the expenses of its publications. Members whose positions enable them to do so are requested to bring to the notice of publicity managers the merits of the *Journal* and *Proceedings* as channels for reaching purchasers of engineering equipment. It is stressed that the *Journal* and both parts of the *Proceedings* have a large circulation oversea and suitable advertisements in them can materially aid the present drive to export more of Britain's electrical products.

As an increasing proportion of commercial and executive positions in industrial, contracting and public organizations become occupied by professional engineers, so do the *Journal* and *Proceedings* reach more and more of those to whom engineering advertisements are directly useful.

A brochure about the *Journal* and *Proceedings* as advertising media, giving full particulars of rates, circulations, etc., may be obtained from the Advertisement Department of The Institution, Terminal House, Grosvenor Gardens, London, S.W.1 (Telephone: Sloane 7266).

EDITORIAL VACANCIES ON THE INSTITUTION STAFF

Applications are invited for the post of Assistant Editor of *Science Abstracts*, for Section B *Electrical Engineering*. The duties will consist of selection of articles from the world's literature, allocation to specialist abstractors, editing the abstracts for publication, and preparation of the subject index. Applicants should have an engineering or science degree or a corresponding qualification, and some knowledge of most branches of electrical engineering. Experience of a research or design department, or of information work connected with such, is desirable. Some acquaintance with at least one foreign language is essential, since a large part of the work will involve examination of foreign publications.

There are also vacancies for Editorial Assistants to work on the *Journal* and *Proceedings* of The Institution. The qualifications required are an engineering or a science degree, some engineering experience, and the ability to write good English and to sub-edit high-class technical copy. A knowledge of foreign languages and some experience of technical journalism would be advantageous.

Applicants for these vacancies should preferably be between the ages of 25 and 30 (approximately). The salaries will depend on age, qualifications and experience. Entry to a superannuation scheme would follow a short period of service. Those who are interested should write to the Secretary, The Institution of Electrical Engineers, Savoy Place, London, W.C.2, giving full particulars of their education, training and experience.

JOURNAL OF THE BRITISH NUCLEAR ENERGY CONFERENCE

It has been decided to publish three issues of the *Journal of The British Nuclear Energy Conference* this year instead of two as was originally announced; the next two issues will therefore appear in July and October, 1956. The price of single copies of this journal has therefore been revised as follows:

To members of the five constituent societies	10s. 0d. each
To non-members	£1 0s. 0d. each

AWARD OF JAMES WATT MEDALS

The Council of The Institution of Civil Engineers have announced that they are presenting James Watt Medals to Mr. T. G. N. Haldane, M.A., PAST-PRESIDENT, and Mr. P. L.

Blackstone, T.D., M.A., MEMBER, for their paper on 'Problems of Hydro-Electric Design in Mixed Thermal-Hydro-Electric Systems', which they presented at a Joint Meeting of The Institutions of Civil and of Electrical Engineers on the 6th January, 1955.

CLEAN AIR

A CONFERENCE AT THE INSTITUTION OF MECHANICAL ENGINEERS

Members of The Institution are invited to participate in a conference on 'The Mechanical Engineer's Contribution to Clean Air', which is being arranged by The Institution of Mechanical Engineers. It will take place early in 1957, although the exact date has not yet been fixed. The conference will be held over two days and will be preceded by an evening session at which Sir Harold Hartley will deliver a lecture on 'Possible Patterns of Fuel and Power Supply over the Next Forty Years'. The subjects on which papers will be presented and discussed include: the efficient and smokeless combustion of fuels; the scope for improvement in flue-gas washing equipment, electrostatic precipitators and mechanical grit arresters; air pollution from road transport; air pollution in coal mines and in the cement manufacturing industry; instrumentation and automatic combustion-control equipment; air pollution from chemical processes; and the elimination of smoke from locomotives and from ships in harbour.

Copies of papers will be available in advance of the conference, and the proceedings, containing the opening lecture, papers and discussions, will be published in due course. Further details may be obtained from the Secretary, The Institution of Mechanical Engineers, 1 Birdcage Walk, London, S.W.1.

PRODUCTION EXHIBITION

The second exhibition sponsored by The Institution of Production Engineers will be held at Olympia from the 23rd to the 31st May, 1956. The aim of the exhibition is to demonstrate the latest techniques for increasing production, and the various sections deal with scientific research, training of management and employees, work study, standardization, the automatic factory, materials, design, and the improvements resulting from workers' suggestion schemes. A conference will be held in conjunction with the exhibition. Further details may be obtained from the Secretary, The Production Exhibition, Andry Montgomery Ltd., 32 Millbank, London, S.W.1.

A TROPHY FOR INDUSTRIAL SAFETY

Every day 180000 industrial workers in Britain receive injuries from accidents which are sufficiently serious to prevent them working for three days or longer. Every day three industrial workers are killed.

To encourage the efforts to reduce these alarming figures, Sir George Earle, Chairman of the Associated Portland Cement Manufacturers, has recently presented a trophy to the Royal Society for Prevention of Accidents. This will be awarded annually for an outstanding contribution to the prevention of industrial accidents. Entry for the award of the trophy is open to industries, local accident prevention groups, and other bodies approved by the R.S.P.A., but not to individuals.

The trophy will be presented each year at the National Industrial Safety Conference of the R.S.P.A., which this year is being held at Scarborough from the 11th to 13th May. Forms of entry for the award and full particulars may be obtained from the Secretary, the Royal Society for the Prevention of Accidents, Terminal House, 52 Grosvenor Gardens, London, S.W.1.

PROCEEDINGS OF A CONFERENCE ON ANALOGUE COMPUTING

The Organizing Committee of the International Conference on Analogue Computing which was held under the auspices of the Société Belge des Ingénieurs des Télécommunications et d'Électronique in Brussels from the 27th September to the 1st October, 1955, announce that the proceedings of this Conference will shortly be available in a single volume. This record is well illustrated and includes in either French or English the texts of the Conference lectures, papers and discussions. The price of the volume, not yet definitely fixed, will be 600–700 Belgian francs (£4 5s.–£5), and copies of it may be ordered from Monsieur Richard Peretz, 50 avenue F. D. Roosevelt, Brussels, Belgium.

SUMMER MEETING IN THE MIDLANDS

The Council regret that, in view of the large number of applications already received for the Summer Meeting in the Midlands, which takes place from the 25th to 29th June this year, no further applications can be accepted.

THE INSTITUTION CONVERSAZIONE AT THE ROYAL FESTIVAL HALL

THURSDAY, 21ST JUNE, 1956

As previously announced an Institution Conversazione will be held at the Royal Festival Hall in the evening of the 21st June this year from 7.45 p.m. until midnight and an application form for tickets is being sent with this issue of the *Journal* to all members in the British Isles. Members from oversea who will be visiting this country at the time and who wish to attend should apply to the Secretary for an application form.

After a reception by the President and Lady Nelson, there will be a concert in the auditorium and dancing in the foyer, where music will be played throughout the evening by George Jay and his Orchestra. The artists for the concert will probably be Adele Leigh (*Soprano*), Beryl Kimber (*Violin*), John Cameron (*Baritone*), Richard Farrell (*Piano*), and Arnold Greir (*Organ*).

There will be a number of exhibits of electrical engineering interest. Buffet refreshments will be available throughout the evening.

The price of tickets is 21s. each and members can apply for up to three tickets in the first instance; they can also ask for a fourth ticket which will be sent to them, if numbers permit, not later than the end of May. Members of Graduate and Student Sections can obtain a single ticket for 15s. or two tickets for 27s. 6d., but for additional tickets the normal price of 21s. each will apply.

Application, accompanied by the appropriate remittance, should be made on the form as early as possible and the tickets will be allotted in the order in which the applications are received. The price of tickets is inclusive with the exception of drinks, obtainable at the cash bars.

Evening dress, dinner jackets or uniform, and decorations will be worn.

Forthcoming Events at Savoy Place

All meetings are held at Savoy Place, beginning at 5.30 p.m. (tea at 5 p.m.), except where otherwise stated. The nature of the meeting is indicated by the following key:

E	EDUCATION DISCUSSION CIRCLE	R	RADIO AND TELECOMMUNICATION SECTION
I	INFORMAL	S	SUPPLY SECTION
M	MEASUREMENT AND CONTROL SECTION	U	UTILIZATION SECTION
O	ORDINARY		

After each paper that has now been published is added the month that its synopsis appeared in the *Journal*.

* No advance information will be available.
† An abstract of the introduction will be available in advance.
§ This paper will be published not later than 10 days before the date of reading.
|| This paper has now been published individually (see p. 254).

APRIL

19 *Thursday*

J. J. BATES, PH.D., AND PROFESSOR A. TUSTIN, M.SC. — U

Temperature Rises in Electrical Machines as Related to the Properties of Thermal Networks (Paper No. 2026 U)|| *Synopsis:* March 1956

PROFESSOR A. TUSTIN, M.SC., AND J. J. BATES, PH.D.

Temperature Rises in Electrical Machines on Variable Load and with Variable Speed (Paper No. 2031 U)|| *Synopsis:* March 1956

PROFESSOR A. TUSTIN, M.SC., D. F. NETTELL, B.SC., AND R. SOLT, B.SC.(ENG.)

Performance and Heating Curves for Motors on Short-Run Duties (Paper No. 2036 U)|| *Synopsis:* March 1956

20 *Friday*

PROFESSOR G. W. CARTER, M.A., will open a discussion on **Theories of Electromagnetic Induction*** (At 6 p.m., tea at 5.30 p.m.) — E

23 *Monday*

Informal evening on **Electronics and Automation**, at which there will be a talk (with films and demonstrations) on **Automatic Assembly Systems for Electronic Equipment** given by G. W. A. DUMMER, M.B.E.† — R and M

25 *Wednesday*

H. C. HALL, M.SC., AND E. KELK, M.SC. — S and M

Physical Properties and Impulse Strength of Paper (Paper No. 2024 S)|| *Synopsis:* March 1956

H. C. HALL, M.SC., AND D. J. SKIPPER, B.SC.(ENG.)

The Impulse Strength of Lapped Impregnated Paper Dielectric (Paper No. 2025 S)|| *Synopsis:* March 1956

W. G. STANDRING, M.A., AND R. C. HUGHES, B.SC.

Breakdown under Impulse Voltages of Solid and Liquid Dielectrics in Combination (Paper No. 2050 S)|| *Synopsis:* March 1956

26 *Thursday*

PROFESSOR A. C. B. LOVELL, O.B.E., PH.D., F.R.S. — O

The Forty-Seventh Kelvin Lecture on **Radio Astronomy***

27 *Friday*

SIR MAURICE BOWRA, F.B.A., M.A.

Second Graham Clark Lecture on **The Impact of Engineering on Society*** (Joint meeting with The Institutions of Civil and of Mechanical Engineers at The Institution of Mechanical Engineers, 1 Birdcage Walk, Westminster, S.W.1. Tickets of admission are now not required).

30 *Monday*

The President will open a discussion on **The Efficient Use of Technical Personnel*** — I

MAY

1 *Tuesday*

F. S. EDWARDS, M.SC., will open a discussion on **Methods of Fault Detection and Location in Impulse Tests on Transformers†** — M and S

Informal evening at which there will be a talk and demonstration on **Stereosonic Recording and Reproduction** given by H. A. M. CLARK, B.SC.(ENG.), and G. F. DUTTON, PH.D., B.SC.(ENG.) (at E.M.I. Studios, 3 Abbey Road, St. John's Wood, London, N.W.8, at 6 p.m.). Admission by ticket only, obtainable from the Secretary of The Institution. — R

2–**4** *Wednesday–Friday*

Convention on Electrical Equipment of Aircraft — U

5 *Saturday*

Supply Section Summer Visit to the Houses of Parliament and Greenwich — S

8 *Tuesday*

J. BELL, M.SC. — M

Lecture on **Ship Stabilization: Automatic Controls, Computed and in Practice***

9 *Wednesday*	L. R. F. HARRIS, M.A. **Time Sharing as a Basis for Electronic Telephone Switching: A Switched-Highways System** (Paper No. 1993 R)‖ *Synopsis:* February 1956	R
11 *Friday*–13 *Sunday*	Utilization Section Summer Visit to Harrogate (See March *Journal*, p. 191)	U
14 *Monday*	PROFESSOR K. A. HAYES, B.SC.(ENG.) will open a discussion on **An Elementary Presentation of the Principles of Magnetism and Electromagnetic Induction,** with demonstrations, before the Education Discussion Circle* (At 6 p.m., tea at 5.30 p.m.)	E
15 *Tuesday*	T. E. GREEN **Mine Locomotives** (Paper No. 2106 U)§ *Synopsis:* See page 254	U
16 *Wednesday*	R. L. HEARN, B.A.SC., D.ENG. Lecture on **The Sir Adam Beck Generating Station No. 2 at Niagara—A Major Canadian Hydro-Electric Development***	S
17 *Thursday*	ANNUAL GENERAL MEETING *followed by* SIR GORDON RUSSELL, C.B.E., M.C. Lecture on **Appearance Design*** (At approximately 6.30 p.m.)	

British Nuclear Energy Conference: Forthcoming Programme

MAY

3 *Thursday*

A meeting sponsored by The Institution of Chemical Engineers will be held at the Royal Institution, Albemarle Street, W.1, at 5.30 p.m. (tea at 5 p.m.)

H. G. DAVEY, O.B.E., M.SC.
Some Problems in the Maintenance of Nuclear Reactors *Synopsis:* See March *Journal*, page 203

JULY

3 *Tuesday to* 6 *Friday*

A Conference on the Physics of Nuclear Reactors, sponsored by The Institute of Physics. This will take place in the building of our Institution.

The purpose of the Conference is to keep members of the British Nuclear Energy Conference abreast of scientific developments in nuclear reactors and to call their attention to the problems needing solution. The Conference is intended particularly for industrial and Government physicists, working directly or indirectly with reactors, and for lecturers and teachers.

The programme, subject to slight modification, is as follows:

3RD JULY

Session 1

3.00 p.m.
The President of The Institute of Physics (SIR JOHN COCKCROFT) to open the Conference and deliver an address on **Scientific Problems in the Generation of Nuclear Power.**

4.00 p.m.
Tea. Exhibits of models of reactors, instruments, etc., will be on view.

7.45–10.00 p.m.
Reception for members of the Conference during which films illustrating reactors and experiments with them will be shown and exhibits will be on view.

4TH JULY

Session 2

10.00 a.m.–12.30 p.m. (*with a break for coffee*)
Lecture by DR. J. R. DIETRICH on **The Physics of Advanced Reactors,** followed by a discussion.

Session 3

2.30 p.m.
Lecture by MR. P. W. MUMMERY on **Experimental Reactor Physics,** followed by a discussion.

4.30 p.m. Tea.

Session 4

8.00 p.m.
Discourse on **Recent Developments in Nuclear Theory** by PROFESSOR R. E. PEIERLS.

5TH JULY

Session 5

10.00 a.m.–12.30 p.m. (*with a break for coffee*)

Lecture by DR. A. H. COTTRELL on **The Effects of Irradiation on the Physical Properties of Solids and its Contribution to the Physics of the Solid State,** followed by a discussion.

Session 6

ANCILLARY PROBLEMS OF REACTORS

2.30 p.m.

Opening papers: DR. G. C. LAURENCE on **Shielding.** DR. A. SALMON on **Control Methods.** MR. W. MACRAE on **Instrumentation.**

4.30 p.m. Tea.

Session 7

8.00–8.45 p.m.

Lecture by DR. R. SPENCE on **The Role of Chemistry in a Nuclear Energy Project.**

8.45–9.30 p.m.

Lecture by MR. R. L. ROTHERHAM on **The Role of Metallurgy in a Nuclear Energy Project.**

6TH JULY

Session 8

RESEARCH REACTORS AND THEIR USES

10.00 a.m.–12.30 p.m. (*with a break for coffee*)

Opening papers: DR. W. B. LEWIS on **The Canadian Research Reactors and their Uses.** MR. F. W. FENNING on **The U.K. Research Reactors and their Uses.** These will be followed by a discussion.

12.30 p.m.

Concluding remarks by the President.

Admission to the Conference will be by ticket only. Some tickets have been allocated to our members, and those who are interested and have not yet applied for tickets should do so immediately. Application forms may be obtained from the Secretary, The Institute of Physics, 47 Belgrave Square, London, S.W.1. There is no fee for tickets, but a charge of 15s. will be made to those attending the reception on the 3rd July, and all participants will be charged 7s. 6d. for light refreshments throughout the Conference.

A Conference handbook giving full details, including abstracts of the papers and lectures, will be issued early in June together with tickets. The proceedings of the Conference will be published as a supplement to the *British Journal of Applied Physics* and, probably, in the *Journal of the British Nuclear Energy Conference.*

NOVEMBER

22 *Thursday and*
23 *Friday*

A Symposium on the Calder Hall Nuclear Power Plant. This is designed to cover all the important features of the planning, design and construction of the plant. There will be five sessions: Introduction and General Design; Technical and Research Problems; Engineering Design; Light and Electrical Engineering; and Future Developments and Summary. About twenty papers will be presented. Further details will be published later.

Elections and Transfers

The following elections and transfers were approved by the Council during February and March, 1956.

ELECTIONS

Associate Members

BALLENDEN, Lewis Balfour, B.SC.
BELL, Eric, B.SC.
BENNETT, Alan Reginald Henry, B.SC.
BIDERMAN, Ervin, B.SC.(ENG.).
BROWN, Charles Harwood, B.SC. (ENG.).
BROWN, Curtis Earthy, B.SC.(ENG.).
COWTAN, Gilbert Francis.
DASGUPTA, Samarendramohon, M.SC.
DEIGHTON, Richard, B.SC.
DEUCHAR, William Gall.
ESCRITT, Colonel George Stanley, M.A.
GHEY, Geoffrey William Essington, M.B.E., M.A.
GREGORY, Arnold, B.ENG.
GRIFFITHS, Alfred John.
HAWKINS, Capt. William Frederick Duncan, B.SC.(ENG.), R. SIGNALS
HESLOP, James Mark.
HOLLINGHURST, Dudley Stuart.
KEEDWELL, Elmer James.
McCANN, Edward.
MUKERJEE, Manmatha Nath, B.SC.
ORR, Horace Claude, B.SC.
PETTERSEN, Johan Wilhelm Eide, B.SC.
PRASAD, Lalit, M.SC., M.A.
SCOTT, Archer.
SZOLD, Andrew, DIPL.ING.
THOMA, Philip Charles Pullen.
TRIER, Peter Eugene, M.A.
VINCENT, Charles Holmes, M.SC.
WHYMAN, Ronald.

Associates

BARCLAY, Thomas Roy.
BARKER, Harry Varley.
BELK, James Leslie.
CLARKE, Edwin Louis.
COLLISTER, Thomas Edward.
COLWILL, Raymond William.
DENNIS, John Pollard.
JAMIESON, Lt.-Cmdr. Jack Revol, R.N.
JONES, Cyril Frank.
McDERMOTT, Wing-Cmdr. Denis, R.A.F.
McHARDY, George.
SINGH, Gurbaksh.
SKINNER, Lt.-Cmdr. William Henry, M.B.E., R.N.
SMITH, Reginald Lewis.
WARDLE, Thomas Robinson.
WELLBY, Kenneth John.

Graduates

AL-SHABIBI, Asad Mohamud Redah.
AMBLER, John Wright.
ANDERSON, Robert Gordon Scott, B.ENG.
ANDREWS, Frederick Stanley.
ANDREWS, John Harold.
ARDERN, Neville Hibbert.
ARKIESON, Ian James.
AS-SAIED, Ibrahim Mohammed.
BADCOCK, Allan William, M.SC.
BAILEY, Kenneth.
BAKER, Pilot Officer Donald Vincent, R.A.F.
BARNED, Alan James.
BATHGATE, Ben Anderson.
BECKETT, Donald Lewis.
BEESWING, Dennis Edwin.
BENNETT, James Arnold.
BENNETT, William Maurice.
BIRD, Edward Sidney.
BIRD, George Harold.
BLAKE, Frank Michael.

Graduates (contd.)

BRANSCOMBE, Derek Ronald Arthur.
BRAY, Derek, B.SC.
BROADEY, John.
BROADHURST, George.
BROWN, Ivor John Alwyn, B.SC.
BRYANT, Greyham Frank.
BUCKNELL, Vernon John.
BUGDEN, John Hyde.
BUTTIMORE, James Anglin.
CAIN, David George.
CALLANAN, Reginald Ronald, B.SC.(ENG.).
CARRODUS, Frank.
CHAVAN, Vithal Bhawoorao.
CLAYTON, Lionel Hubert William.
COMER, Alec William.
CORY-WRIGHT, John Silston, B.E., B.SC.
COX, Joe.
COY, Cyril Leyland.
CROSSMAN, Jim.
DANIELS, Stanley Reginald.
DARLINGTON, Norman.
DEAN, Gordon Bruce.
DEAR, Leslie Donald.
DEENEY, Aldred.
DEMAINE, Harry.
DRAKOS, Yannakis Costa.
DROMEY, Gordon.
DUDENEY, Peter Nigel.
DYSON, Peter Edward Franklin.
ELAM, Trevor.
EMMETT, Frederick Mervyn.
EVANS, Dewi.
EVANS, Terence Kinsey.
EVANS, William Davidson.
EYRE, Wilfred Lewis.
FLINN, Patrick, B.SC.(ENG.).
FRATER, Richard James, B.A.
FURNISS, Colin.
GANGULEE, Amalendu, B.SC.
GARE, Graham Frederick, B.SC.(ENG.).
GARRETT, Norman Edward.
GEVERT, Jörn.
GILLARD, Dennis Alfred.
GILLETT, Roy William, B.SC.(ENG.).
GLENTWORTH, Frederick Joseph.
GOLDFINCH, William John, B.SC. (ENG.).
HAMILTON, Neville.
HANDS, Edward, B.SC.(ENG.).
HARNDEN, Peter Charles.
HARRISON, Lawrence Martin.
HARRISS, Victor George.
HARVEY, Dennis Edwin Alfred.
HAYWOOD, James John.
HEPWORTH, Brian.
HIGGINS, John Francis, B.E.
HIND, Pilot Officer Keith, R.A.F.
HIRST, John Raymond.
HOLMES, Kenneth Roy.
HOPKINS, David Lamond.
HOWARTH, Frank.
INOMA, Raphael Ejoh.
JENKINSON, Jeremy Mark.
KANDIL, El-Sadek Amin, B.SC., PH.D.
KNIGHT, Gerald Montagu.
LLOYD, John Francis James.
LOBLEY, Pilot Officer Graham Victor, R.A.F.
LOLAYEKAR, Nagesh Gangaram.
McGOW, Peter Charles.
MAKEPEACE, Harry.
MALONEY, Terence Charles.
MARLEY, William Bradley.
MARRIOTT, Albert Edward.
MAUCHEL, Derek John.
MAYBERRY, Anthony Charles.
MEENEHAN, Michael.
NAMBIAR, Kunnath Puthiyaveetil Padmanabhan, B.SC.
NICHOLLS, Albert Ernest James.
OATLEY, John William, B.A.
PEBERDY, Raymond John.
PHELPS, Donald Raymond.
PHILLIPS, Dennis Philip.
PUTLAND, Ronald James.
RADHAKRISHNAN, Avadai.
REED, John Willis.
REILLY, Hedley Victor.
ROE, Harold John.
SAVAGE, Kenneth Frederick.
SHALOM, Mordecai.
SILVESTER, Arthur John.
SIMONS, Richard Alan.
SMITH, Edward Joseph.
SMITH, Peter William, B.SC.
SMITH, Ronald Joseph.
SMITH, William Samuel.
SPEAK, Derrick.
STALLWORTHY, Berwick Vyse, M.A.
STEPHENSON, David James Keir.
STOCKS, Henry.
STUTTARD, Bernard, B.SC.
SWINSTEAD, Robert Hillyard, B.A.
TAYLOR, John Robert.
TAYLOR, William.
TRIBE, Leonard Thomas.
VEITCH, Gordon.
VIDLER, Reginald John Brian.
WEBSTER, Glen.
WILKINSON, Peter.
WILLIAMS, Leslie George.
WILTSHIRE, Donald, B.A.
WOOD, John.
WOZNICA, Leopold.

Students

ADAIR, John Frederick.
BACH, Eric Findlay.
BANCROFT, James Edward.
BAYES, Douglas Vincent.
BETHEL, Peter Ivan.
BOMFORD, David Anthony.
BOND, Arthur Denis.
BOWERS, David Laurence Killingbeck.
BURGESS, Richard, B.SC.
CHAUHAN, Nand Kumar Singh, B.SC.
COOK, John Michael William.
COUTTS, Francis James.
CROMIE, William John.
CULLEN, Edgar Goldsmith Elliott.
DAGLESS, John Leslie.
DATAR, Mohan Kant, B.SC., B.E.
DAVENPORT, Albert.
DE JONG, Clement Victor Anton, B.SC.(ENG.).
DINNAGE, John Dennis.
ELLIS, George Robert.
ERETT, Peter John.
EVERY, Norman John.
GOOLD, Stuart Alan.
GOULD, Reginald Dennis.
GRIME, John.
GUNASEKERA, George Oscar Samarasinghe, B.SC.
GUPTA, Prem Prakash, B.SC.
HACKWORTH, Timothy William.
HARTLEY, Michael George, B.SC. TECH.
JOHNSTON, Robert Kay.
JONES, Kenneth.
KARAGEORGIS, Ulysses.
KARUNARATNE, Naiyandikarayalage Samarajeewa.
KENDELL, Roy.
KENTUCK, Terence.
KILL, Cyril Ronald.
LELE, Dinkar Gajanan.
LLOYD, Robert James, B.SC.
McCUNE, Robert.
MANNALL, Peter Sydney.
MEHTA, Jayantilal Sukhlal.
MILNE, Ian James.
MOLE, Harvey Albert.
MORRIS, Roger Brian, B.A.
NORONHA, Leonardo Gastao.
PAGE, David Dunkerley.
PRAMANIK, Ashutosh, M.SC.
PRICE, Joseph Boyd Simms, B.SC.
PUGH, Alan.
PUGHE, Arthur Edward.
RICKARD, Donald.
RISSO, Arthur James.
ROUTLEDGE, Donald Malcolm.
SAMAD, Mohammed Abdul.

Students (contd.)

SECKER, Philip Edward.
SENADHIPATHY, Don Gunapala. B.SC.(ENG.).
SHACKLETON, John Michael.
SHEPARD, John Glover.
SUTTON, Alan John.
TANDON, Brij Kishore, B.SC.
THAPAR, Baldev, B.A., B.SC.(ENG.).
THOMAS, Norman Theo.
THOMPSON, Arthur John Campbell.
WEBBER, Samuel Thomas.
WIJENATHAN, Doraisamy.
WILLIAMSON, Thomas James.
WRAGG, Anthony.

TRANSFERS

Associate Member to Member

ADDENBROOKE, John Hibell.
BEAUFOY, Samuel, B.SC.(ENG.).
CARPENTER, Alan Bertram.
DALTON, Sir John Cornelius Joseph.
DENHAM, Humphrey John, C.B.E., M.A., D.SC.
DONNELLY, George Matthew Ferguson.
FYFE, Reginald John, B.SC.
HALL, Peter Dudley, B.SC.
HUMBY, Albert Maurice.
KUMAR, Pratap, B.SC.(ENG.).
LANGTON, Leslie Lancelot.
LLOYD, Harold.
LOVE, Kenneth George.
McDERMOTT, William, B.SC.TECH.
MAHALINGAM, Narayanier, B.A.
MAWSON, Spurgeon.
NOTT, John Arkell, B.SC.(ENG.).
PIM, John Albert, B.SC.(ENG.)., PH.D.
PRITCHARD, Stephen Percival.
RINIA, Herre.
SAMSON, George Albert.
SHARP, Leonard William Descarrieres, M.A.
SQUIRE, Philip James, B.SC.(ENG.).

Associate to Associate Member

KELSALL, George.
OVERTON, William Francis.
WINGROVE, Arthur George.

Graduate to Associate Member

ADLINGTON, Maurice John.
ALMOND, Albert George.
BAKER, Denis.
BALDWIN, Theo, B.SC.(ENG.).
BARKER, Norman.
BARONI, Paul Robert.
BARRASS, Robert.
BETTINSON, Sydney Francis.
BHATTACHARYA, Peejush Kiron, B.A.
BOLTON, Wallace.
BRYANT, Norman Samuel, B.SC. (ENG.).
BUCHANAN, George.
BUTLER, John Rowland.
CAWLEY, Anthony.
CHANT, Leonard James, B.SC.(ENG.).
CHAPMAN, David Gordon.
CHASTON, Robert Henry, B.SC.(ENG.).
CLAYTON, Herbert Edward.
CONNOR, George.
CRICHTON, Albert.
CROOK, Desmond Walter Ewart, B.SC.(ENG.).
CROOKS, Stanley George, B.SC.(ENG.).
CUMMACK, John Bycroft, B.SC.
DALZIEL, Robert.
DAVIS, Derek, M.ENG.
DAWES, Trevor Franklyn.
DEAN, David Brian, B.SC.
DEB, Sukhendu Bikas, M.SC.
DIAMOND, Samuel.
DWEK, Maurice Désiré, B.SC.(ENG.).
EDNEY, Colin James.
EYRE, Bernard Edward.
FARR, Dennis Sidney.
FLEMING, John Harfield, B.SC.
FLETCHER, John Howard.
FLUDZINSKI, Jan Mieczyslaw.
FOOT, Henry James, B.SC.(ENG.).
FORBES, Eric Douglas, B.SC.(ENG.).
FRAME, Geoffrey, B.SC.
GARLAND-COLLINS, Lt.-Col. Thomas Kenyon, B.SC., R.E.M.E.
GILL, Frederick Denis, B.SC.(ENG.).
GOODBOURN, Francis Henry Hugh.
GRIFFIN, Rodney.
GRIFFITHS, Frederick Leonard.
HADRILL, Harold Frederick John, M.ENG.
HALL, Gordon Bannister, B.SC.TECH.
HARTILL, Reginald, B.SC.(ENG.).
HEARNE, Derek Victor, B.SC.(ENG.).
HEATH, Gerald William.
HEDGECOCK, Basil Hugh, B.SC. (ENG.).
HIGNETT, Kenneth Cecil.
HIRST, Henry, B.SC.
HOOD, William Gordon Duncan.
HOODLESS, Ronald.
HOVEY, Patrick Bruce, B.E.
HOWE, James Turner, B.A.
HUGHES, Lt. John Matthew Llewellyn, M.A., R.N.
HUNT, Richard Stephen.
JENKINS, David Edgar Prytherch, B.SC.
JONES, Thomas Robert Wyndham.
JONSCHER, Andrzej Karol, B.SC. (ENG.), PH.D.
JOYNER, Thomas Robert, B.SC.
KAYSER, Harold David, B.SC.
KELSEY, Dennis Machen.
KINNAIRD, James Henry, B.SC. (ENG.).
LEADER, Donald Norris, B.SC.(ENG.), PH.D.
LEITCH, Douglas Victor John.
McLEOD, Allan James.
MERCER, Jack, B.SC.TECH.
MILLER, Alan William, M.A.
MORRIS, Henry.
MUMFORD, Howard.
OAKLEY, Roy.
OWEN, John Quail, B.SC.
PAGE, Douglas Alfred.
PAJAK, Boleslaw, B.SC.(ENG.).
PAJAK, Stanislaw Wladyslaw.
PARROTT, Peter George, B.SC.(ENG.).
PEPLOW, Maldwyn Edward, B.SC.
PHILLIPS, Owen Herbert, B.SC.(ENG.).
PHILLIPS, William.
REECE, Michael Peter, B.SC.(ENG.).
RUSHALL, Peter Graham, B.SC.(ENG.).
SAUNDERS, James Ernest.
SCAIFE, William Garrett Stanley, B.SC.(ENG.).
SCOTT, Christopher Paton.
SEED, Michael Geoffrey, B.SC.
SHOULTS, Charles Martin, B.SC. TECH.
SMARIDGE, Stanley Richard, B.SC.(ENG.).
SMITH, Alfred Edward.
SMITH, John Macken, B.SC.
SNOWBALL, William Ronald, B.SC.
SOUTHWOOD, James Robert Mitchell, B.SC.
SPEAR, Donald Frederick, B.SC.(ENG.).
STALEWSKI, Antoni.

Graduate to Associate Member (contd.)

STENSON, Alexander Vivian Wyvin.
STIRTON, David, B.SC.(ENG.).
SUMMERS, Raymond Basil.
TAIT, William.
TATE, Douglas Gibson.
TAYLOR, John Malcolm, B.SC.
TAYLOR, Raymond William.
TOLMIE, John Williams, B.SC.(ENG.).
WATSON, George Ross.
WHEELER, Harry Hilton, B.SC.(ENG.).
WHITTAKER, Robert James, B.SC.
WRIGHT, John Willoughby Thomas.

Student to Associate Member

ROME, Thomas Peter.

Student to Graduate

BAILEY, Richard Grenville, B.A.
BARTON, John Dalton.
BENGHIAT, Raphael, B.SC.(ENG.).
BETTS, Arthur, B.ENG.
BICKLEY, John, B.SC.(ENG.).
BOARDMAN, Derek, B.SC.
BREWERTON, Donald Alfred John.
BRISLAND, Derek Wulstan, B.SC.
BROWN, Alan Boiston.
BURFIELD, Robert.
BYARD-JONES, Michael James, B.SC.(ENG.).
CALLENDER, Thomas Paul.
CAPELL, Geoffrey John, B.SC.
CAPON, Malcolm John.
COCKETT, Roland, B.SC.TECH.
COLES, Albert Edward.
COLLIER, Fl.-Officer Peter Anthony, R.C.A.F.
CONSTANTINIDES, Christos Theodorou, B.SC.TECH.
COOPER, John Wyatt.
DALGLIESH, Peter Leslie.
DAVID, Frederick Arthur Duffus, B.SC.(ENG.).
DOBNEY, Robert James.
DUFF, Alan John, B.SC.(ENG.).
ELDRED, Raymond William.
ELLIS, Edward Lovell, B.SC.(ENG.).
ETHERINGTON, Peter John, B.SC. (ENG.).
FEDO, John Frederick.
FORSTER, John Hills.

Student to Graduate (contd.)

GILBERT, Gerald.
GILLMAN, John Harry.
GREEN, John Conrad.
HAMPSHIRE, Frank.
HARRIS, Ian Richard.
HARRISON, John.
HARROWER, Kenneth Douglas.
HILTON, Maurice.
HOOPER, Edmund Peter Jack, B.SC. (ENG.).
JAMES, David John Dicks, B.SC.
JENKINS, Dewi Price, B.SC.(ENG.).
JONES, Elwyn.
KENYON, Douglas Bernard.
KERR, Frederick.
LOPIANOWSKI, Narcyz Marek, B.SC.(ENG.).
LOWE, Terence John.
McDONALD, Richard Gibb, B.SC.
McINTOSH, David John.
McKEOWN, Richard Thompson.
McKERNAN, Thomas Alexander.
McMILLAN, William Ian.
McNEILL, Michael Bennett.
MALLETT, Leonard Samuel.
MATTHEWS, Roy Denis, B.SC.(ENG.).
MATTHIAS, Granville Brian.
MAXFIELD, Graham, B.ENG.
MILLER, Robert Arthur.
MINSHULL, Michael Oliver.
MOLLOY-VICKERS, John Anthony.
NG, Cheong Kiong, B.SC.(ENG.).
OHRENSTEIN, Charles.
OSBORNE, Mostyn Arnold.
PARE, Clifford Frederick.
PARK, Allan Thomas.
PARTRIDGE, Roy Godfrey.
RICE, William Mitton, B.E.
ROGERS, Martin Richard Newsome.
ROSE, John Foster, B.SC.(ENG.).
ROSS, Alexander.
SANDERSON, Frank Colin.
SCOTT, Stewart Morton, B.SC.
SMITH, David Sydney John.
STAMPS, Reginald John.
STREET, Brian Dudley Frederick, B.A.
TAYLOR, Joseph Howard, B.SC.(ENG.).
TROMANS, Kenneth.
UTTING, George Vere.
VERSTEEGH, Arnold Jan, B.SC.(ENG.).
WARRINGTON, John Derek.
WERBSKI, Joseph.
WHITTAKER, Peter George.
WILLIAMS, Glanfor.
WILLIAMS, Norman Eustace.
WILLIS, Peter Rendle Percival.
WILLISON, Michael John Leslie.

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March 1956 **Germanium and Silicon Power Rectifiers** (PAPER NO. 1936 U, OCTOBER 1955)

C. CUTHBERT, B.SC., AND D. A. PICKEN
January 1956 **Timing the Operation of Control Systems associated with Rotating Equipment** (PAPER NO. 1800 U, MARCH 1955)

D. HARRISON, M.ENG., PH.D.
January 1956 **The Dynamic Braking of Induction Motors** (PAPER NO. 1885 U, AUGUST 1955)

J. S. MØLLERHØJ, M.SC., A. M. MORGAN, B.SC.(ENG.), AND C. T. W. SUTTON, M.SC.(ENG.)
January 1956 **Flat Pressure Cable** (PAPER NO. 1884 S, JULY 1955)

D. H. LUCAS, B.A., AND M. E. PEPLOW, B.SC.
April 1956 **The Measurement of Steam Temperatures in Power Stations** (PAPER NO. 1872 S, JUNE 1955)

V. A. PASK, C.B.E.
April 1956 **Power Stations and their Equipment** (*A Review of Progress*) (PAPER NO. 1954)

Discussion on **The Adhesion of Electric Locomotives** before the North-Western Centre

Written discussion on **The Solution of Gas in Oil during Transformer Filling**

Written discussion on **An Examination of High-Voltage D.C. Testing applied to Large Stator Windings**

Written discussion on **The Overhaul and Maintenance of Direct-Current Traction Motors**

Discussion on **The Possibilities of a Cross-Channel Power Link between the British and French Supply** Systems before the North-Western Supply Group, the South Midland Centre, the South-East Scotland Sub-Centre, the South-West Scotland Sub-Centre, the Rugby Sub-Centre, the Southern Centre, the Western Centre, the Northern Ireland Centre, the Mersey and North Wales Centre, the North-Eastern Centre, the North Staffordshire Sub-Centre and the North Midland Centre

Discussion on **A Brushless Variable-Speed Induction Motor** before the South Midland Supply and Utilization Group and the North-Western Utilization Group

PART B. RADIO AND ELECTRONIC ENGINEERING (MARCH 1956)

See *Journal*, March 1956, page 205.

PART C. MONOGRAPHS (MARCH 1956)

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